COLLEGE OF ENGINEERING CORNELL UNIVERSITY

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PAID
Ithaca, N.Y.

the Cornell engineer

MARCH, 1957
VOL. 22, NO. 6
25 CENTS

Member of the Engineering College Magazines Associated

Chairman: Prof. Robert W. Bohl, University of Illinois, Urbana, Illinois
Publishers' Representatives, Littell-Murray-Barnhill, Inc., 369 Lexington Ave., New York and 605 N. Michigan Ave., Chicago

Founded 1885

THE CORNELL

engineer

MARCH 1957 VOLUME 22 NO. 6

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Published monthly—October to May—by the CORNELL ENGINEER, Inc., Lincoln Hall, Ithaca, N. Y. Edited by the undergraduates of the College of Engineering, Cornell University. Entered as second class matter at the Post Office at Ithaca, N. Y., under Section 103, Act of October 3, 1917.

Subscription per year: regular \$2.00; with membership in the Cornell Society of Engineers \$3.00; student \$1.50; single copy \$.25.

Only 13 when he succeeded his father as head of many Mongol clans, Genghis Khan grew to be the 13th century's mightiest conqueror, his empire extending from the China Sea almost to the Baltic. The success of Genghis Khan's mounted troops rested on their exceptional discipline, speed, ruggedness . . . and the remarkable flexibility and practicality of their armor . . .

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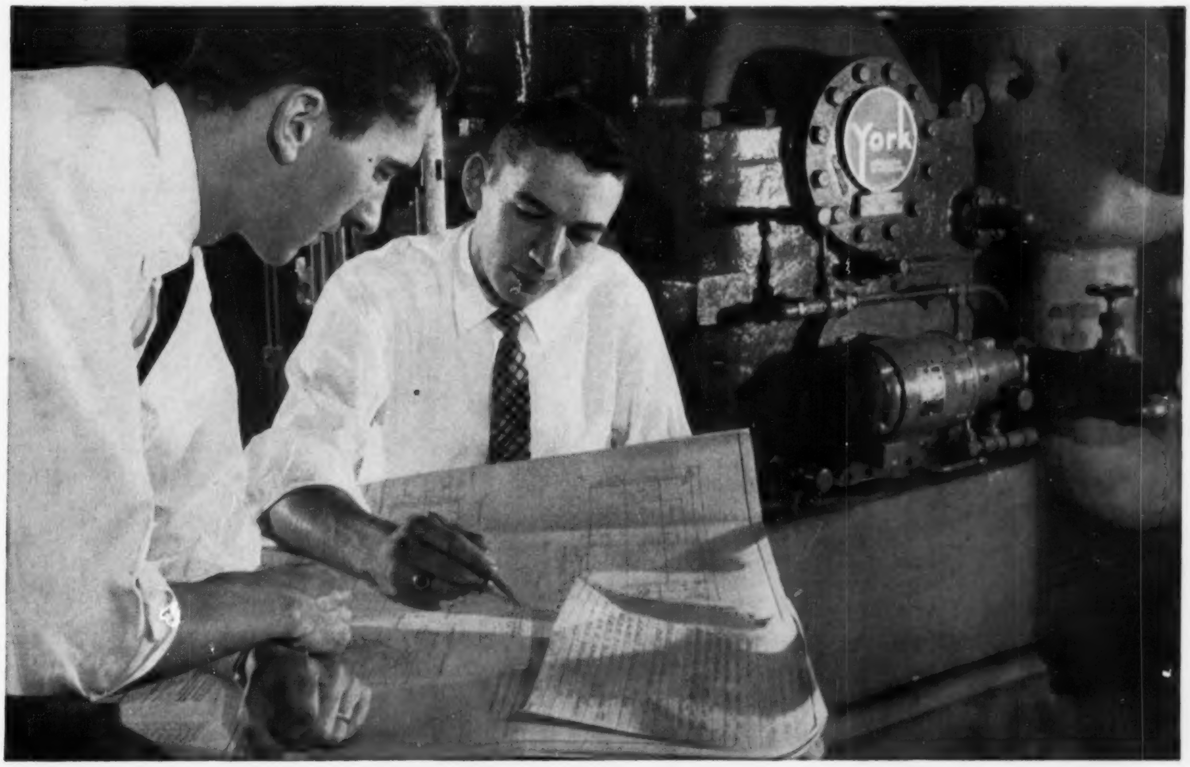
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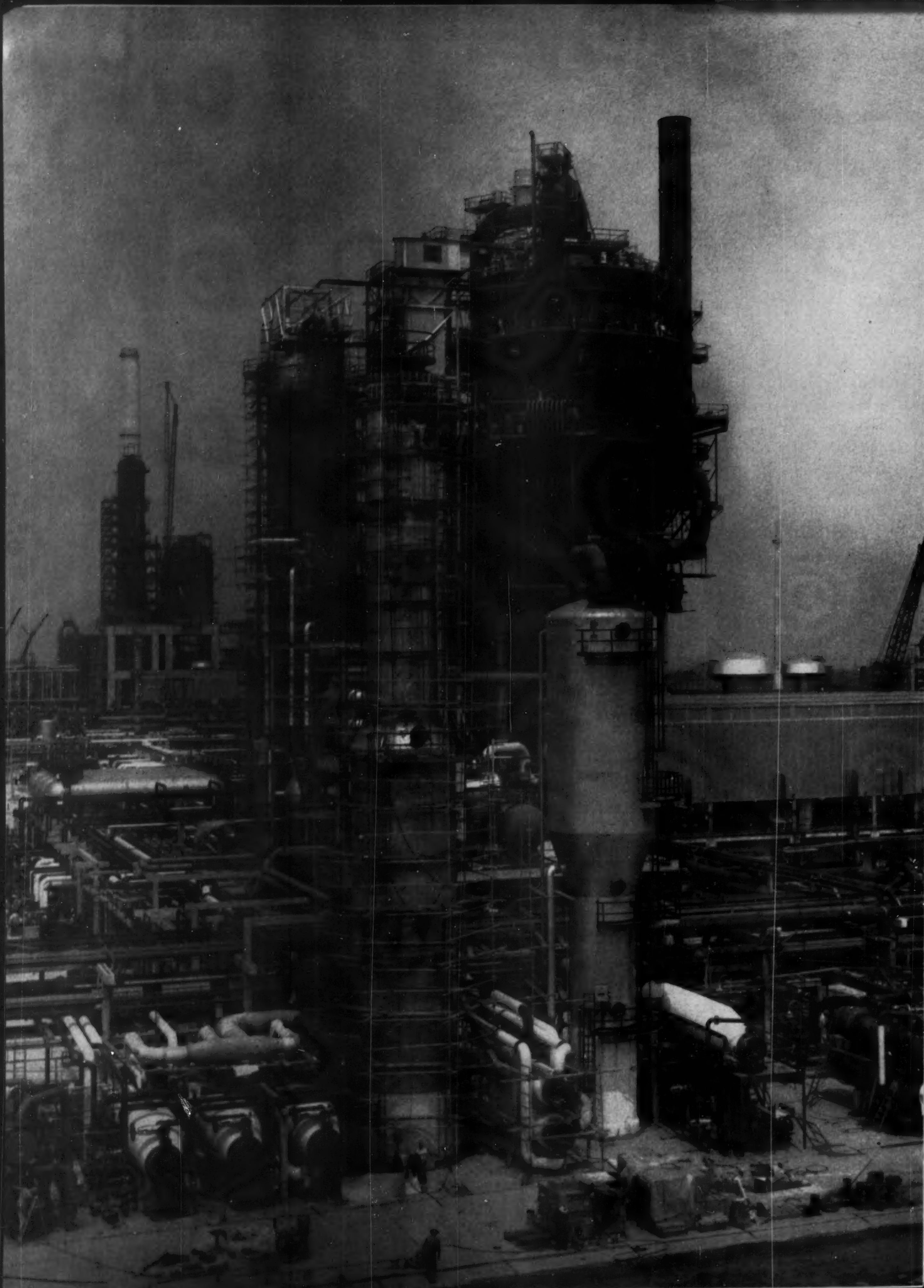

CLAD STEELS

THEIR APPLICATIONS IN INDUSTRIAL DESIGN

by

W. E. Mullestein, CE '32

Almost as old as metalworking itself is the art of cladding two or more metals. In the past, the sole purpose was one of economy, as exemplified in the ancient art of bonding a thin layer of gold or silver onto a base of copper or brass. Jewelry items made of these materials are known today as gold filled and silver filled. In recent times, the reasons for cladding have extended to the achievement of special properties. Copper-clad cookware and bimetallic thermostat elements are familiar in our modern life.

Lukens clad steels are the heavy industry members of this class of materials. They have been made in gages from $\frac{3}{16}''$ to 8⅝", in widths to 178" and in lengths to 480".

Development and Manufacture

The development of Lukens clad steels was originally prompted by the desire to provide economical corrosion resistant materials in place of expensive solid alloy metals. The first of these was nickel-clad, developed in 1930 as a joint effort between Lukens Steel Company and The International Nickel Company. Today, they include Monel and Inconel, the chromium stainless steels, the chromium-nickel stainless steels and copper. Developmental work is in progress on other materials, such as titanium, zirconium and the Hastelloys.

The base metal is usually low carbon steel but may be any one of a large variety of carbon and low alloy steels. Advantage may be taken of the high temperature properties of the carbon-moly or chrome-moly steels and of the sub-zero temperature properties of nickel steels.

Lukens clad steels are manufactured by preparing a "sandwich" which, after assembly, is hot rolled as an ingot. In preparing the "sandwich", a heavy slab of steel of the desired mechanical properties is thoroughly cleaned on one of its flat surfaces. A plate of cladding material which has been nickel plated on the surface to be bonded is placed on the steel slab. A second similarly prepared slab of steel and cladding material is placed on top of the first one with an infusible parting compound between the alloy inserts. The cladding material inserts are made slightly smaller than the steel slabs. Spacer bars of carbon steel are placed around the edges of the inserts. This "sandwich" or pack is then sealed by welding completely around the edges. The composite pack is heated in a soaking pit to a temperature of 2100 to 2350°F., depending on the type of cladding, or at lower temperatures for copper-clad, and then rolled on Lukens large 206" mill. After rolling, the pack is sheared or flame cut inside the welded edges and separated into two clad steel plates.

Unique with Lukens clad steels is the nickel plating which: (1) aids in bonding, as nickel is soluble in all proportions in steel and in the alloy claddings; (2) protects the alloy surfaces from oxidation during heating before bonding; and (3) acts as a barrier to migration of carbon from the backing steel into the cladding.

Heat treatment, if required, is done at this point. For example, the austenitic stainless-clad steels are heat treated at high temperatures to dissolve carbides. Chromium stainless-clad steels and clads with low alloy backing steel are given appropriate heat treatment.

Clad Steel plates, with the exception of copper-clad steels which are sand blasted, are usually descaled at Lukens by the sodium hydride process. This consists in immersing the clad plates in a bath of molten caustic soda at 700°F. in which 1.2% to 1.7% sodium hydride has been produced by the reaction of metallic sodium and hydrogen. The sodium hydride, which is a strong reducing agent, converts the scale to metal or lower metallic oxides which can be removed by water spraying with hot water. A sulfuric acid bath is used to neutralize the caustic, and a nitric-hydrofluoric acid bath is used to passivate stainless-clad steel plates.

The high temperatures and pressures of hot rolling used in the manufacture of Lukens clad steels weld the components together completely and inseparably by a chemical or intermolecular bond. The strength of the bond is proved by the standard ASME method of shear testing. The ASME Boiler Code and ASTM Specifications require a minimum bond shear strength of 20,000 psi for clad steels.

The clad thickness is normally specified as a percentage of the total thickness of the composite clad steel plate. The most common thicknesses are 10% and 20%. For corrosion resistant applications, users usually specify from $\frac{1}{16}''$ to $\frac{1}{8}''$ of cladding. Most commercial fabricators prefer that the minimum thickness of clad be held to 0.030".

During the rolling process, the cladding and backing steels are reduced in thickness together at the

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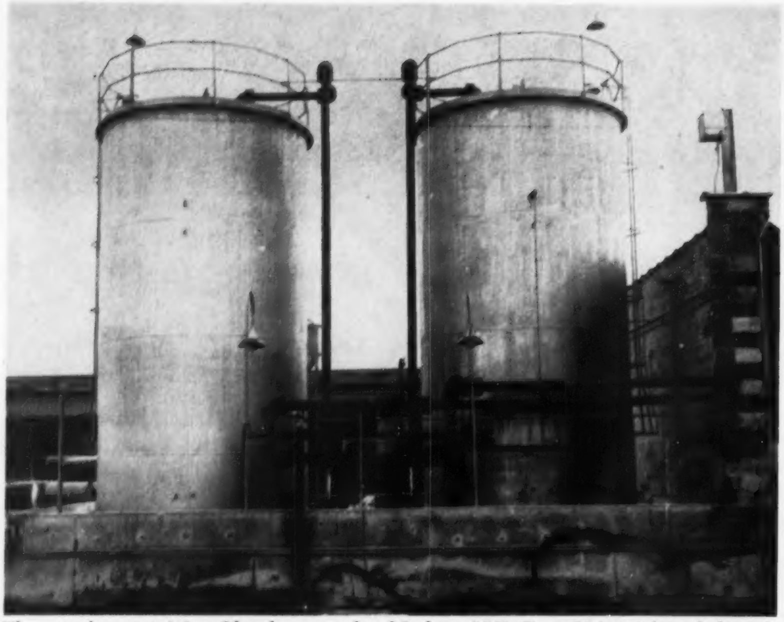
One of clad steel's many uses in the modern refinery is illustrated by this large cat cracker.



These tanks, containing Glycol, are made of Lukens 10% Type 304 stainless-clad steel. The clad steel will serve to insure the product's purity while in storage.

same rate. The precise control over the thicknesses of the cladding inserts and the backing steel slabs during assembly of the "sandwich", which Lukens employs, results in a finished clad steel plate with uniform thickness of cladding.

Design

Since a large part of the clad material produced is used in pressure vessels, it is necessary to consider ASME Boiler Code requirements. Historically, integral-clad steel, such as that produced by Lukens, was first accepted for pressure vessels under Case 896 in 1941 and, more recently, as part UCL of Section VIII of the 1952 and 1955 ASME Codes. Under Code rules, it is permissible to use the full thickness of the composite plate in design calculations.

In general, the design of clad steel pressure vessels and other types of equipment will follow conventional methods; however, designs must be used that will maintain a continuous clad surface and prevent any contact of the corrosive environment with the backing steel. Many different designs for providing continuity of the cladding at nozzle openings, joints and flanges are employed.

Savings in material costs of from 25% to 50% are possible in clad over solid alloy construction. Welding costs are about the same in light gages and less in heavy gages. In addition, forming operations, such as bending and rolling, are easier. Shop equipment may be lighter and less power is required.

Advantages and Uses

Since steel is a good conductor of heat compared with most of the metals used for cladding, vessels made of clad steel have an advantage over many of their solid counterparts. Because of the continuous intermolecular bond of clad steel plate, thermal conductivity is not significantly impaired across the bond line; and the heat conductivity of clad steel plate in the percentages normally used, therefore, will approach the high heat transfer rates of carbon steel. Two exceptions, of course, are copper- and nickel-clad steels; however, the advantage of the stainless-clad steels is significant.

The advances of modern technology place increased demands on materials of construction. Clad steels are meeting this challenge, as well as providing a means of conserving scarce metals and alloys. For example, the reactor for the atomic power plant at Shippingport, Pa., was made with 8-5/8" thick Type 304 stainless clad on Type A-302 alloy backing steel; the high strength steel for the high temperatures and pressures involved and the stainless cladding to combat the corrosive effect of high temperature water which might contam-

ABOUT THE AUTHOR

W. E. Mullestein is general manager of sales for Lukens Steel Company and a member of the company's management committee.

He was graduated from Cornell University in 1932, as a civil engineer, and studied law at New York University. Prior to joining Lukens in 1944, he was assistant superintendent of the Dewey and Almy Chemical Co., from October 1943 to August 1944; director of the construction division of the War Production Board, from February 1942 to October 1943; and secretary of the building code committee of the American Iron and Steel Institute, from October 1939 to February 1942.

Mullestein started with Lukens sales organization 12 years ago. He was serving as assistant manager of sales for the Lukenweld Division when in 1945 he was granted a leave of absence to go to Europe as a member of the U. S. Strategic Bombing Survey. Upon his return he became manager of sales of Lukens Coatesville District Sales Office. He was promoted to manager of field sales in May 1947 and named to his present position in May 1954.

W. E. Mullestein

He is a member of the American Society for Naval Engineers, American Ordnance Association, American Iron and Steel Institute, Cornell Club, and Cornell Engineering Society.

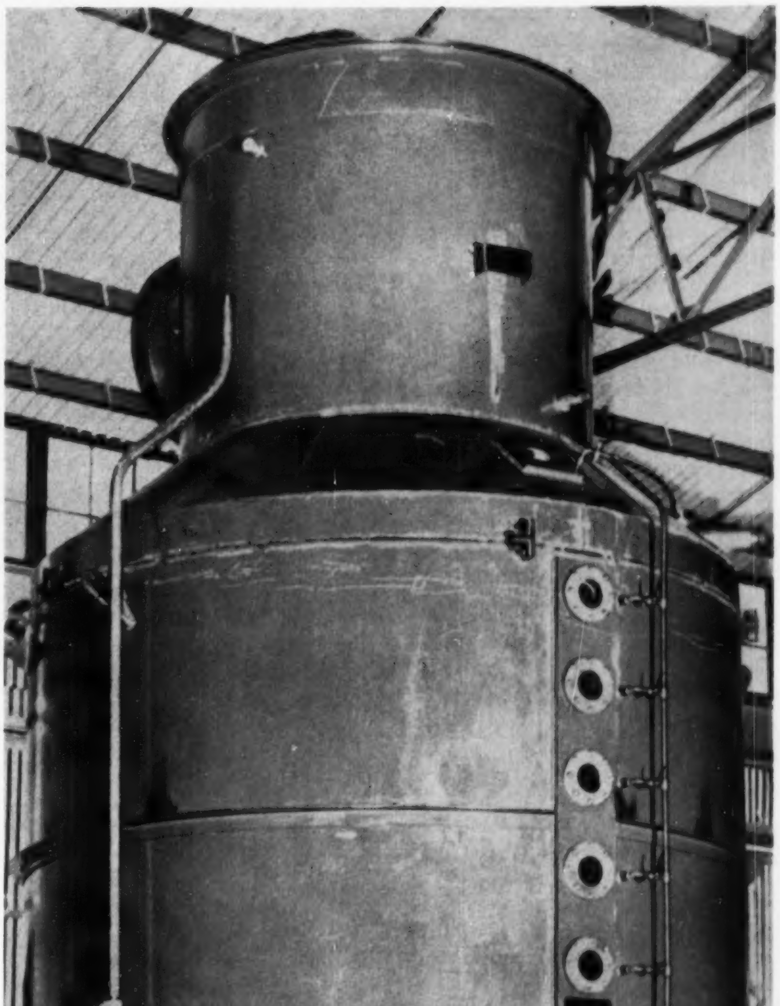
inate the primary coolant with radioactive materials.

High temperatures and high pressures are becoming common in modern chemical and petroleum processing. As these increase, the corrosion problem becomes increasingly severe in most cases. The use of clad steels in gages from 2" to 6" is not uncommon and is growing steadily.

Large tonnage of all types of clad steel plates are used in petroleum refining equipment. One of the first applications was the use of Monel-clad in the upper portion of crude towers where strong mineral acids, such as hydrochloric, tend to concentrate. In other sections of these towers, 12 chromium stainless-clad is used to combat high temperature sulfur corrosion. The 18-8 stainless-clad steels, containing molybdenum, are used where naphthenic acids are encountered. These same types of clad steels are employed to combat the same corrosives in catalytic cracking and thermal cracking vessels and in the towers and other vessels associated with these units.

Hydrofluoric acid and phosphoric acid are used for certain isomerization and polymerization processes. Monel-clad and Type 316L (low carbon) are used, respectively, for refining equipment handling these mineral acids. Other reagents for treating petroleum products include caustic and sulfuric acid. Nickel-clad steel is useful for caustic, and Monel-clad is useful for dilute sulfuric acid. Of special interest is the process called desulfurization, in which the petroleum hydro-carbons are treated with hydrogen at high pressures and high temperatures. The hydrogen-hydrogen sulfide mixture formed is very corrosive under these conditions, requiring the use of stainless alloys. Stabilized austenitic stainless-clad steel plates, such as Type 321, and 12 chrome stainless-clad steel plates in thicknesses to 3" have been used.

Uses for clad steels in the petrochemical industry include reactors, columns, tanks and heat exchangers; specific examples are: copper-clad for the manufacture of ethyl alcohol; Type 316 stainless-clad for formaldehyde, acetic acid and naphthenic acids; nickel-clad for glycerin; and Type 316L stainless



The Lukens nickel-clad steel, from which this large sugar evaporator was fabricated, protects the unit against corrosion and helps assure complete purity of product.

for the phosphoric acid catalyst used to produce phenol.

Applications of clad steels in the chemical industry are wide and varied. An outstanding example is the alkali industry where nickel-clad and Monel-clad have become the standard materials for handling concentrated hot solutions of sodium hydroxide and sodium chloride salt brines respectively. Closely associated to this industry from the corrosive standpoint is the soap, fatty acid, oils and glycerin industry. Here nickel-clad is used to preserve product purity, in addition to resisting corrosion. Monel-clad finds applications in processes involving sodium chloride and dilute sulfuric acid. Inconel-clad and Type 316 stainless steel clad are excellent choices for fatty acids at high temperature, such as are involved in high pressure fat splitting and high temperature distillation.

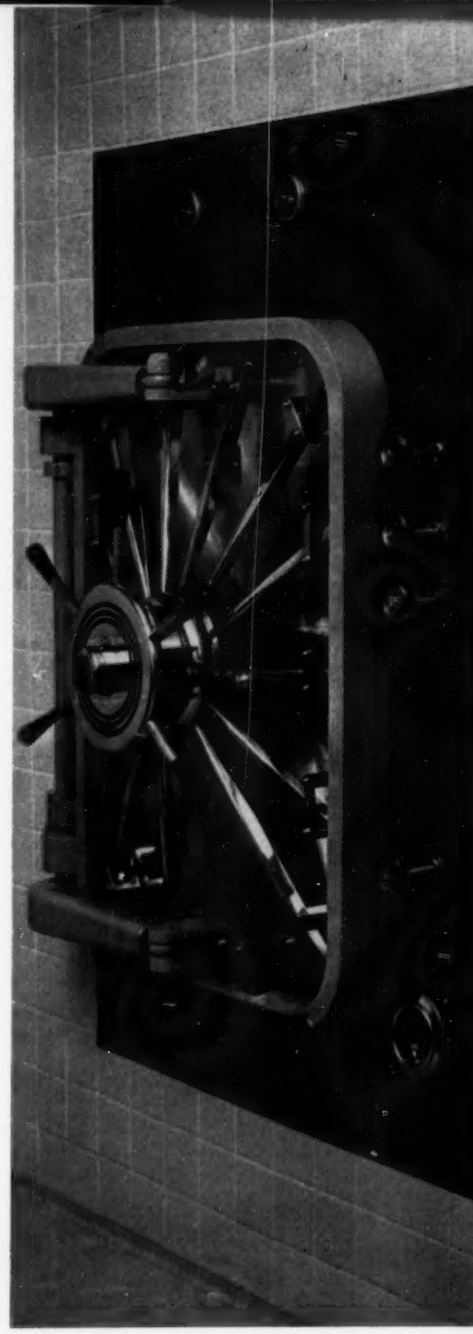
In the pulp and paper industry, clad steels have been used for pulp digesters, head boxes and for evaporators and tanks handling corrosive chemical solutions.

In the pharmaceutical industries where the protection of product purity is foremost, stainless-clad and nickel-clad have been used for equipment as fermenters, extractors, evaporators, sterilizers, driers and mixers.

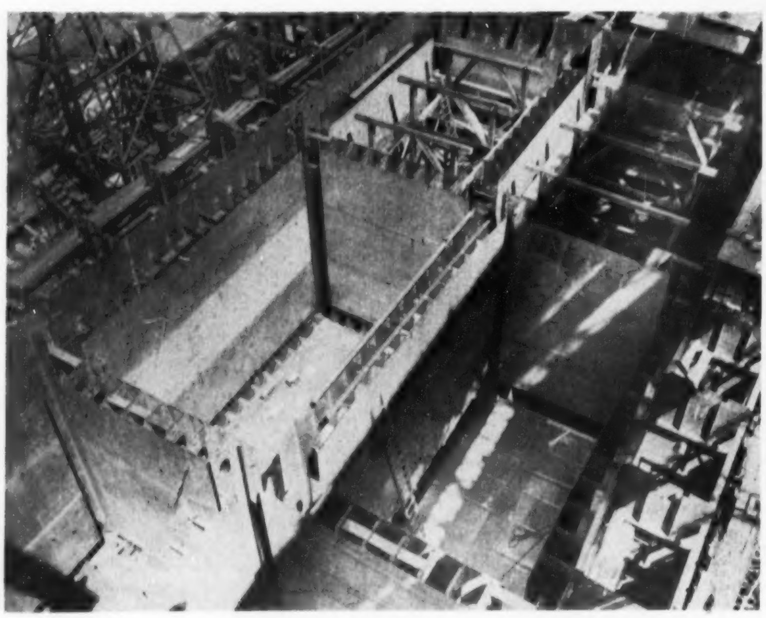
Clad steels are used for similar reasons in the food processing industries and for combating the corrosive nature of certain foods and processing reagents. Nickel-clad steel is used for vacuum pans in sugar refining and for evaporators for glucose. Stainless-clad steels are used extensively for such items as mixers, evaporators, cooking tanks and kettles. In the last two applications, the high heat conductivity of stainless-clad may be advantageous over the solid alloy.

For metal heat treatment clad steels have been used as a material for fused salt baths and molten metal pots with the clad steel surface sometimes on the outside and sometimes on the inside. Gas-fired fused sodium chloride salt baths, for example, operating at 1600°F. have used stainless cladding on the outside to resist oxidation. On the other hand, electrically heated molten sodium nitrate, potassium nitrate heat treatment baths operating at 1000°F. have been made with L-nickel (low carbon) cladding on the inside. Another interesting high temperature application is the use of Type 304 stainless-clad for titanium reducing retorts where temperatures to 1800°F. are obtained during the production cycle. As was anticipated from laboratory heating and quenching tests, there was no deterioration of the bond between the cladding and backing steel in these high temperature applications.

(Continued on Page 36)



The nickel-clad chamber doors of this large pressure sterilizer resist lactic acid and hospital solutions and permit processing at around 200° to 225°F.



The low corrosion rate of nickel-clad steel is one of the factors which make it useful for these tanks. The tanks will hold 73% caustic acid at 230°F.

EDUCATION IN INDUSTRY

IBM TRAINING INCLUDES CORNELL PROGRAM

by
Richard Brandenburg, ME '58

Employee education ranging from graduate study in engineering and physics to a cooperative program providing secretarial training for high school girls is a basic part of the operating philosophy of the International Business Machines Corporation. The annual budget for all types of educational activities conducted by IBM is more than the expense of operating many large universities. A technician training program conducted in cooperation with Cornell University is the most recent example of IBM's desire to develop talent from within its own organization by educating its employees.

A variety of areas are covered by IBM sponsored courses and programs. The IBM Department of Education offers courses for employees, customers and special professional groups. A General Education Program includes adult education courses in Business, Technical, Engineering, and General Divisions. A graduate program in Mechanical and Electrical Engineering is conducted in cooperation with Syracuse University. Specialized training is given in engineering, sales, customer engineering, and other technical work.

Extension course material is used for field employees unable to attend regular classes. Courses are given for customer personnel in IBM accounting and data processing, including statistical and computing methods. At the Watson Laboratory at Columbia University an extensive teaching program is conducted in conjunction with laboratory work in machine and mathematical research and computation methods. IBM also cooperates with colleges and universities where IBM accounting and statistical methods are taught.

Special programs conducted by IBM include toolmaker apprentice training, secretarial coop programs with high schools, and annual management school sessions in which top level executives discuss their problems together free from routine interruptions.

Cornell Teaches IBM Technicians

One of IBM's most recent large scale educational ventures is the Undergraduate Engineering Training Program now in progress at Cornell University. The purpose of the program is to train participants to become technically qualified to assume basic engineering responsibilities. The program attempts to gain better usage of employees by providing them with an opportunity to cultivate their technical talents. In addition the plan alleviates the engineer shortage at IBM by freeing engineers for more advanced problems.

Selection of the first group of twenty students to participate in the program was made on the basis of educational and job experience, desire to participate, and competitive examinations. Each employee's record and test results were turned over to Cornell for final selection. Last summer the students stayed at the Delta Upsilon Fraternity house while taking regular courses included in the Cornell undergraduate engineering curriculum.

The program began with a fourteen week summer course that started June 11. Instruction during the Fall term consisted of one course presented in Endicott by a Cornell professor. In like manner a single course will be taught in Endicott during the spring term. Next summer the students will return to the Cornell Campus for a second and final 14 week session. By then the students will have completed 43 credit hours in basic math, physics, electrical engineering and English offered a Cornell undergraduate.

Professor C. L. Cottrell of the School of Electrical Engineering has been named by the University as Special Class Advisor. Instructors participating in the program are: Professor D. P. Randall from Syracuse University who taught physics in the special summer program, Professor W. R. Keast of the English Department, Morris Schreiber, Mathematics Instructor, and J. V. Sanders, Graduate Assistant Instructor in Physics.

The students took three freshman engineering courses during the first term of the summer session: Math 161, Physics 115, and English 111. During the second term of the summer session, they took Math 162, Physics 116, and Drawing 3112. This past fall, Math 163 was taught at IBM facilities by Mr. Stanley Leja, and during the spring, Electrical Engineering 4110 will be presented by Professor E. M. Strong. Next summer, students will take Math 607, EE 4111, and Physics 117. The program will conclude with EE 4112, 4116, and 4121. Thus with heavy emphasis on electrical engineering, the students will get a thorough grounding in engineering courses enabling them to handle numerous basic engineering problems on the job.

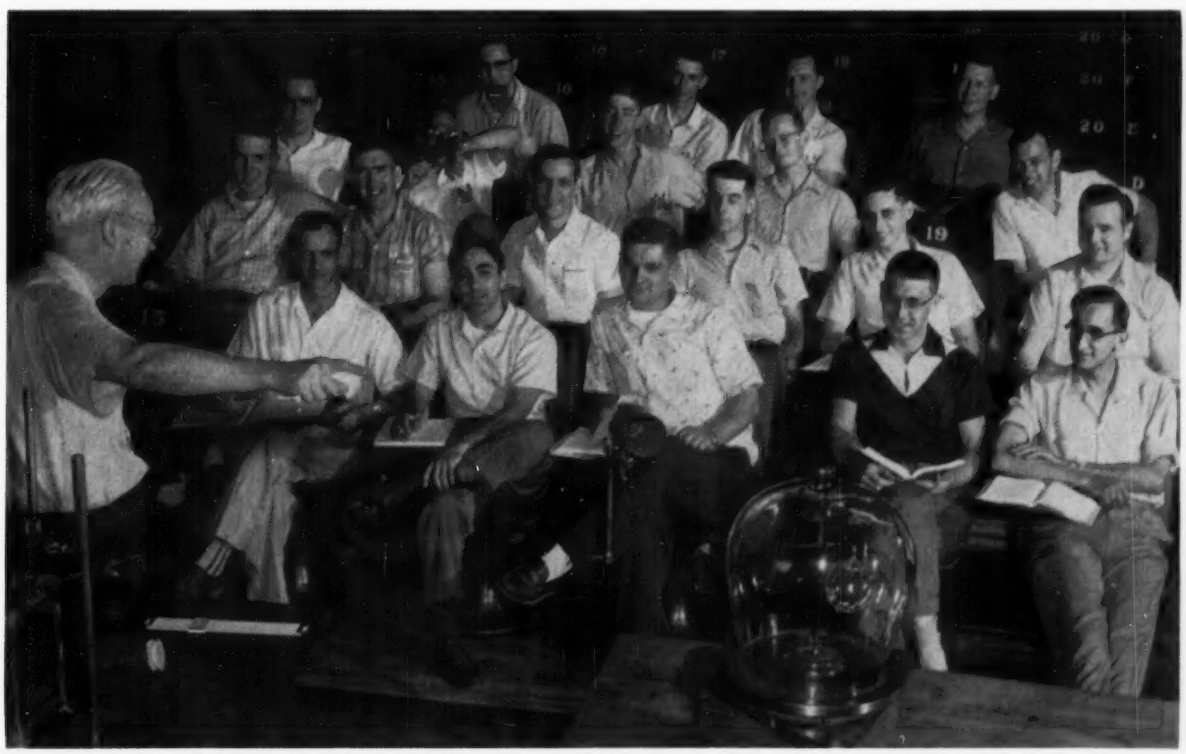
At present, IBM officials are evaluating the merits of continuing the Undergraduate Engineering Training Program at Cornell. The first group of twenty students will be the basis for deciding the overall benefits and methods of future programs. The apparent success of the program to date is indicated by remarks made by Dean of the College of Engineering S. C. Hollister, and Mr. C. I. Johnson, General Manager of the IBM Airborne Computer Laboratory, at a dinner held in Statler Hall at the close of last summer's session. Dean Hollister stated the program was proving to be extremely worthwhile. Mr. Johnson reported that IBM is pleased with the progress of the program.

Both Cornell Faculty and IBM officials believe the Undergraduate Training Program is a means by which the University can serve industry, and by which industry can reduce the effect upon national welfare of the shortage of technically trained workers.

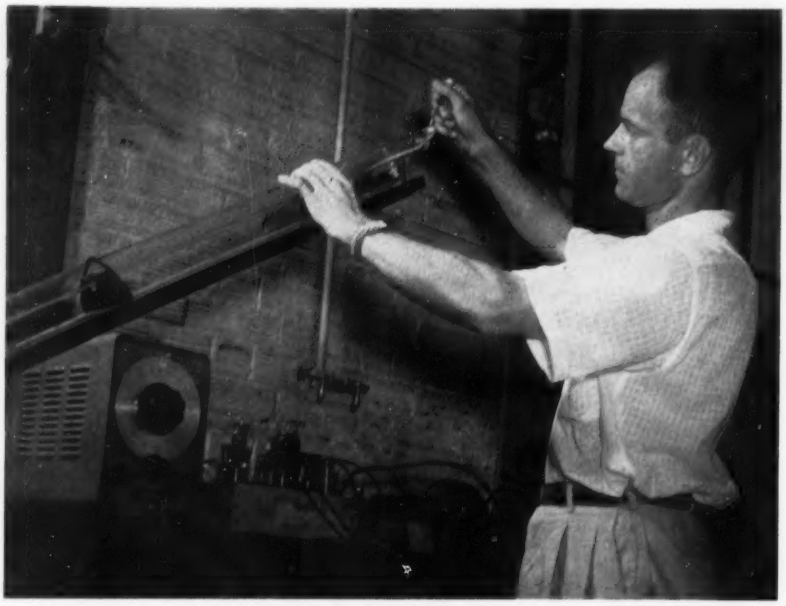
New Engineers Get Thorough Training

Typical of IBM emphasis on education is the eight to nine month training program for new engineering employees. The program is conducted on three levels—orientation to job situation; company products and policy; technical training related to mechanical and electrical product design; and personal development courses to benefit the individual employee. The program, scheduled as a full time training assignment for two weeks and then half a day of classes combined with half a day on the job, is geared to the needs of the individual trainee as well as the job assignments involved.

The IBM Commercial Products Laboratory in Endicott, New York, offers a typical engineer training program in which the trainee is assigned to part time rotational job



IBM students watch Professor D. P. Randall perform a lecture demonstration in Physics 115.



Student W. L. Smith prepares a Physics 115 experiment to measure the speed of sound in air.

assignments when his classes are not in session. These job assignments are with active projects involving many phases of laboratory operations. Staff instructors, senior engineers, plant managers and specialists are teachers for the program.

An evaluation is made of each trainee to help him determine his progress during the training period in terms of class performance, personal characteristics, and fundamental abilities. Personal interviews with staff instructors are encouraged for individuals desiring guidance in a specific area. Upon satisfactory completion of the training program, each engineer submits a letter to the engineering personnel manager stating job preference and reasons for his choice. Final placement is made on the basis of departmental needs and the qualifications and desires of the individual.

The curriculum of the engineering trainee program at Endicott reflects the thorough backgrounding IBM gives new engineering employees. Orientation courses include: Principles of Data Processing, Computer Programming, and IBM Organization. Technical courses for electrical and physics majors include: Principles of Circuit Logic, Computer Principles, Electronic Digital Computer Circuit Design, Electronics Laboratory and Instrumentation, and Electronic Packaging Practices.

Mechanical majors take the following technical courses: Principles of Computer Electronics, Computer Principles, Machine Design Analysis and Application, Design Standards and Practices, Experimental Mechanical Measurements and Instrumentation, and Manufacturing and Assembly Practices. Courses in Technical Reporting and Creative Engineering are combined with student- conducted seminars to aid trainee personal development. In addition, trainees are assigned to a branch office for two weeks to acquaint them with problems related to IBM equipment encountered in the field.

Graduate Study Sponsored

IBM cooperates with Syracuse University in maintaining a program leading to a Master's Degree in Mechanical Engineering, Electrical Engineering, or Physics. Courses are conducted after working hours in classroom facilities located at IBM plants in Endicott and Poughkeepsie. Two periods of an hour and a quarter each separated by a dinner hour make up an evening's class program. The teaching staff consists of professors on Syracuse University's regular graduate school staff.

The graduate degree program includes extensive counseling for individual students to aid in planning an actual course program and in developing an approach to graduate study. Each student is assigned a faculty advisor from the department in which he expects to earn his degree. Out of class informal discussion is encouraged as a valuable means of developing individual capacity for creative engineering work. Career development counseling is conducted by IBM department managers, provid-

Three students pool their knowledge to solve a problem in Physics lab.

Professor C. L. Cottrell, special Class Advisor, talks with students participating in the Undergraduate Engineering Training Program.

ing a balance of advice that aids students both academically and in terms of job experience.

Students generally carry one course per semester, thereby earning their Master's Degree in ten semesters or less. The IBM-Syracuse University graduate program represents industry-education teamwork designed to give individuals with ability and initiative a chance for self development that makes them more creative engineers.

Program Improves Technician Abilities

An Electronic Technician Training Program conducted in IBM plants prepares graduates of two year technical schools and persons with equivalent work experience to assume many responsibilities otherwise given to graduate engineers. The engineers are thus freed for more advanced assignments, thereby enabling more effective utilization of limited technical manpower. The full time program consists of ten 40 hour weeks and meets in two-hour-long sessions. Classes of no more than twenty students are conducted by two full time instructors. Other IBM personnel are used for specialized topics. Laboratory equipment, text materials, and course notes are provided by IBM. Students are carefully selected on the basis of a special aptitude test and records of work experience.

Courses included in the Technicians Training Program range from a study of the basic units of IBM machines to the design of computer and magnetic circuits. Program administrators realize that the training does not prepare all graduates to assume design responsibility. Rather, IBM management expects as a minimum result that the technicians will be above average members of development teams with high potential for future growth.

General Education Covers Many Subjects

Enrollment in any phase of IBM's General Education Program is an entirely voluntary step that enables an employee to receive instruction in four divisions: Business, Technical, Engineering, and General subjects. Qualified IBM personnel as well as school and university faculty members are utilized as teachers. Classes meet two hours once a week for a total of twelve weeks.

Courses in the Division of Business Education are designed to present basic business administration skills and practices. Some of the typical courses include: IBM products, Electronic Accounting Machine Practice, Data Processing, Typewriting, Shorthand, Accounting, and Everyday Law.

Technical Division courses are presented on the level of technical institute training and include courses in IBM machine principles, mathematics, electricity and electronics, industrial practice, mechanics and materials, and manufacturing and production. Engineering Division courses provide advanced training for graduate engineers. Courses are offered in the fields of mechanics and materials, mathematics and physics, electricity and electronics and computers.

The General Education Division rounds out the overall education program by offering courses to enhance employee personal development. Psychology, speaking, report writing, conference leadership, and creative thinking are representative of the General Division subjects.

Specialized courses offered only to employees working in a particular phase of company operations may be added to the General Education curriculum.

IBM aids educational institutions desiring to offer course work in data processing and computers. Schools may obtain IBM equipment for instructional purposes at a discount of 20%. An additional 20% discount is given if the school teaches a regular course in data processing from the scientific or business viewpoint.

Recognizing that formal education, including engineering courses, can provide only a basic background for an individual in a given field, IBM has attempted on a large scale to supplement basic employee knowledge with further training to develop more competent, creative workers. Extensive engineering orientation, graduate study conducted at IBM facilities, a broad general education program, and the Undergraduate Engineering Training Program in cooperation with Cornell University reflect IBM's emphasis on encouraging employees to improve their abilities.

The reason for IBM's accent on education is summed up in the words of the President of the International Business Machine Corporation, Mr. T. J. Watson, Jr.: "Knowledge, supported by intelligence, ambition and initiative, is a valuable asset. The more knowledge we can put to work, the more we can accomplish, in our own interests and in the interests of others."

Faculty Profile . . .

Professor N. R. GAY

by
A. S. Rosenthal, EE '60

One of Cornell's outstanding professors in the College of Mechanical Engineering recently changed his area of research from heat-power engineering to the subject of housing. The problem of finding a new home and moving into it has been occupying the time of Professor Norman R. Gay and his family of five since he decided to accept a position in industry. After more than ten years at Cornell, Professor N. R. Gay has left to work for the Bendix-Westinghouse Company at Elyria, Ohio.

Born in Cortland, New York on August 17, 1919, Professor Gay began his engineering studies at the University of Rochester where he received his bachelor of science degree in mechanical engineering. At Rochester, he ranked first in his class and graduated with distinction. Despite his high scholastic achievements, Prof. Gay still found time to be President of the Student's Association, President of Psi Upsilon Fraternity, and President of the Newman Club.

Among the varsity sports in which he participated were track, basketball, and football, serving as co-captain of that team. He was elected to Phi Beta Kappa, Tau Beta Pi, Chi Rho, Mendicants, and Kaedaeans. While at Rochester he held the Rochester Prize Scholarship and was awarded the Terry Prize.

After graduating from Rochester in 1941, Prof. Gay was offered posts at Cornell University and California Institute of Technology. At that time the position of John Edson Sweet Research Associate was open at Cornell, and, when it was offered to him, he accepted it. While serving as Research Associate, Professor Gay spent much of his time teaching. He also worked with F. O. Ellenwood and N. Kulik to ascertain the specific heats of certain gases over wide ranges of pressures and temperatures. Much of the data they collected is accepted today as standard in the engineering world.

While doing this teaching and experimental work, Prof. Gay succeeded in earning credits for a master's degree, but his work was cut short by World War II. From 1944 to 1946 he was an Engineering and Executive Officer in the Navy.

In 1946 he was discharged from the Navy as a Reserve Lt. (jg). He returned to Cornell as an assistant professor and received his masters degree. Here he continued his work in the field of thermal engineering while teaching many different courses. In fact, during the time he has been here, Professor Gay has taught almost every course in the thermal engineering department.

Although he has taught a very wide variety of courses, he tends to specialize in the refrigeration and air-conditioning field. One of the many refrigeration labs which Prof. Gay recalls is one in which the students are required to use the large York refrigeration unit. Aside from illustrating some of the basic principles of refrigeration, one portion of the experiment requires the student to open or close one of two

valves through which water flows under pressure. The experimenter must make certain that one of the two valves is always open. Many students have fallen victim to the old adage, "He who hesitates . . .", while getting a refrigerated shower from a burst pipe; water is—after all—incompressible.

In 1948 Professor Gay became an associate professor. His work at that time dealt with the determination of certain constants that would ease the computation work of the engineer. This work has been largely in the field of air-conditioning. Formally, an engineer who was air-conditioning a large building would have had to consider the many variables which could permit heat to enter a structure. Professor Gay's work in the field has produced much information on the rate of heat transfer by glass, walls, and other media. His work in this area saves the engineer the work involved in solving several differential equations.

Professor Gay's work in the field of heat and power engineering also includes various bulletins dealing with general methods to be employed in choosing and installing suitable heating and air-conditioning facilities. In 1948 he and Professor C. O. Mackey worked together to study some of the thermodynamic aspects of jet engines. A full account of this work appeared in the CORNELL ENGINEER.*

While at the University, Professor Gay devoted his time to many activities other than study and research. He is a member of the American Society of Engineering Education, formerly treasurer of the Cornell chapter of the American Association of University Professors, and on several committees of the American Society of Heating and Air-Conditioning Engineers.

At Cornell the Professor was elected to Sigma Xi, Pi Tau Sigma, and Atmos Society. He was a member of the University Committee on the Scheduling of Public Events. His continued interest in collegiate athletics is evidenced by his membership in the University Committee on Physical Education and Athletics. He was also chairman of the Sibley Faculty Society on founding.

As a member of the three man General Committee of the Mechanical Engineering School, he acted on cases involving students who had fallen below the Mechanical Engineering College requirements. Although this committee's job is not always pleasant, it serves a happier purpose in that it studies any unusual student schedule changes and reviews the entire course of study in the M.E. School. Prof. Gay feels, therefore, that by serving on this committee he helped promote the welfare of both the students and the faculty in the Mechanical Engineering School.

Naturally, Professor Gay will miss many aspects of university life. He feels, however, that there are many phases of industry which will prove valuable to him, as an engineer. While working for Bendix-Westinghouse, he hopes to continue his studies and research to some extent. Both the students and faculty of the engineering school wish him the best of luck in his new undertaking.

* Mackey, C. O. & Gay, N. R., "A Thermodynamic Analysis of Jet Engines, THE CORNELL ENGINEER, May, 1948, Vol. 13, No. 8.

THE ENGINEERING STUDENT:

The problem and promise of his profession in a nuclear age

Engineering students face a world that drastically needs their skills and magnifies the weaknesses of their training. The ability of engineers to increase productivity and living standards with new power sources as well as shrink the world with high speed airplanes is a significant factor in modern living. But there is the menace of nuclear weapons. Millions of men, women, and children are hungry—physically and spiritually. There is racial friction and hot and cold wars. These facts challenge engineers to cultivate a broad perspective in an age of specialization. The development of that perspective and the awareness of a human as well as technical challenge in the future, should begin in the education of the undergraduate engineer. He must begin not only to acquire the skills of his vocation, but to mold his habits of mind and personal philosophy.

To focus on tomorrow's challenge for today's engineering students, THE CORNELL ENGINEER presents a four part symposium: "The Engineering Student—The Problem and Promise of His Profession in a Nuclear Age." The viewpoints of four men prominent in differing fields have been included in order to approach the role of the technically trained person in the modern world from four perspectives important to the student. John H. Hick, Assistant Professor of Philosophy at Cornell University presents the view of a teacher of the Humanities. Dr. J. L. Zwingle, Vice President of Cornell University, offers the view of an educator. Dr. Glenn A. Olds, Director of Cornell United Religious Work, discusses the need to relate a working philosophy to engineering practice. Mr. Glenn B. Warren, Vice President and Consulting Engineer of the Turbine Division of the General Electric Company views the engineering student and his choice of profession as a leader in industry.

The symposium is not intended to offer profound conclusions for the problems and possibilities facing engineering students. Rather, it is designed to stimulate thought about personal attitudes and goals that determine the effectiveness of an engineer in his work. The four contributors have attempted to look ahead, realizing, in the words of Charles Kettering, that we must stop "backing into the future . . . The future is the greatest natural asset we have. You make its value, depending on how you think."

The symposium was prepared to encourage engineering students to inventory their preparation for work against the background of man's struggle for survival. Powerful social and political forces will influence and direct the use of natural forces and materials. Increasingly complex technology will have increasing effect upon the lives of more and more men. Thus the engineer's obligation to society will go beyond the limits of his specialty as he is called upon to bridge the gap of misunderstanding about his work, to communicate the import and benefits of his creations.

The challenge of leadership will require today's engineering students to *understand* the ideas and beliefs of their fellow men and to *effectively communicate* their own ideas to others. Intellectual competence in technical subjects must be buttressed by creative imagination and courage to think beyond the confines of training or experience. The four contributors have attempted to provide a stimulus for evaluating the means and ends of engineering education and life work.

To be most effective as a student, competent in his profession, and creative as a human being, an engineer needs a personal working philosophy that relates him to the challenge of his time. THE CORNELL ENGINEER's symposium, "The Engineering Student—The Problem and Promise of His Profession in a Nuclear Age," is based on the premise that meaningful living involves more than making a living. The articles are offered to students, engineering faculty, and men in industry to stimulate thinking about the future of their profession. The editors realize that building a personal philosophy is a lifelong project based on ideas and experiences that constantly challenge basic beliefs. They hope that the articles will provide a basis for reevaluation of the role and responsibility of engineers in a world that needs not only their technical skill, but also their ability to understand and resolve human needs.

—*by* RICHARD BRANDENBURG, ME '58

THE ENGINEER:

A MAN WITH RESPONSIBILITY

by

J. L. Zwingle,

Vice President, Cornell University

The country needs more engineers. This news is blasted at us every day, in every possible way. Yet the high schools are teaching less mathematics and physics than ever before; and scientific subjects in general are suffering a decline both in qualified teachers and in interested students.

Picture the freshman engineer at Cornell. He faces five long years of hard study. He looks around him and decides that nobody else is studying so hard. Yet if he reads the opinions expressed about engineering education, he learns that even after he has graduated, he probably will not be considered educated. He himself looks with some scorn, mingled perhaps with a little envy, at his fellow students in other fields and wonders, sometimes out loud, where justice has fled.

In the last hundred years, even in the last fifty years, the place of engineering among the vocations has changed so rapidly that the facts elude us. Hardly a moment's reflection is required to understand that in engineering we now have one of the great new professions. The engineer and the scientist stand together as key figures in the sheer maintenance of our economy, to say nothing of the leadership required of these people in forecasting the future and developing the means to meet it.

With the ever-increasing range of scientific knowledge and the ever-new means of production, more and more time is required to train engineers and scientists. How shall we organize a course of studies for these people which will make them competent technically and make them competent as human beings? This is a leading question in educational statesmanship today. As might be expected, however, it is very hard to break the grip of habit, to re-examine the educational program anew. Cornell made a great stride in this direction —at great expense, too—when it adopted the five-year program for engineering. It took courageous leadership to take this step right when the foolish prediction was made that engineers would soon be in oversupply.

At the center of this decision was the word "profession." In past centuries the great professional studies were theology, law, and medicine. Yet not long ago, in this country, professional preparation for these professions was highly irregular. One could become a lawyer by passing the bar examination after apprenticeship in a law office. It is still possible to prepare for the law

ABOUT THE AUTHOR

Dr. J. L. Zwingle came to Cornell in 1955 to assume the responsibilities of Vice President for long range development. He had previously been President of Park College, Parkville, Mo., since 1947.

He has held teaching and administrative posts at the University of Tennessee and at Cornell, and has had experience in all aspects of college work including student personnel, adult education, and public relations.

During World War II, Dr. Zwingle was regional director of the USO for six southern states. In 1946, he became national director of USO operations. Dr. Zwingle received his Master of Arts Degree at the University of Tennessee, and his Ph. D. in English at Cornell.

by attending night school. Yet anyone who seriously contemplates a career in law today undertakes a full four-year undergraduate course in Liberal Arts and three years in a graduate school of law. At the end of three years in law, the candidate receives another *bachelor's* degree. He then is listed as Mr. Prospective Lawyer, A.B., LL.B. If he wishes to do advanced work in law, he spends still more time.

While theological training is not yet as clearly crystallized as legal training, the best practice demands the same thing as preparation for the law—seven years for two Bachelor's degrees (B.A., B.D.). In medicine we have seen the most rapid advance in requirements for professional certification. Fifty years ago medical education was most irregular. Now, however, we find not only the requirement for a Bachelor's degree and a minimum of three years of preparation for the degree of Doctor of Medicine, but also the additional requirements of an internship and a residency, followed by further training if one is to qualify as a specialist.

Now as to engineering a university is faced with two conflicting circumstances: first, the problem of greatly increased enrollment, which necessitates every possible increase in educational efficiency; second, the need for ever-increasing subject matter in engineering education. Clearly we cannot have it both ways.

How then could a university resolve this conflict? First, let us remember that education is always approximate. In dealing with such a complex matter as the development of the human mind and personality, it is fatal to assume that any system is perfect or can produce absolutely predictable results. Essentially all a university can do is to provide the circumstances in which an individual can educate himself. Unfortunately we seem to have reversed this picture in American education, assuming falsely that the primary burden of education is on the institution. The university does have, however, a great responsibility for providing the best system possible, one that will make the right kind of demands on the student, one that will stimulate him to the maximum, hold him to the maximum performance, assist him in every way possible once he has demonstrated his own initiative and determination.

Second, it must be recognized that the university cannot assume responsibility for making up all the deficiencies of preparation.

Third, the university must assume that the student will continue his education after he has graduated, formally or informally, and thus that the university cannot hold itself responsible for teaching the student everything he is ever expected to know.

The central problem of organization for engineering education in a university then is the selection of those things which are absolutely fundamental both for general education and for professional education; and to err on the side of general education, assuming that inevitably there will be a certain element of error in the system. To achieve more professional status, the engineering graduate must become more of a philosopher and less of a technician. Hence he must have some formal instruction in those subjects which stimulate philosophical habits of mind and a professional outlook on engineering as the discipline upon the work of the individual.

How then should the university bring these abstractions into reality? In fact, the central administration can do little except raise the questions. It is a job which can be done only by the faculty and the students. No scheme of education is worth any more than the effort of the individual to make it work. Further, as is true of all matters of educational policy, this is not simply the responsibility of the engineering teachers, but one which concerns the entire university faculty.

To summarize a few opinions:

the five years now required at Cornell for engineering education should probably be increased to six;

the trisemester year should be studied as a possible improvement over the present two-semester year;

the proportion of general education for engineering should be reserved for at least the third or fourth year if not the fourth and fifth year of a six-year program;

industry should cooperate with the university in more programs of advanced education after the engineer has been at work in his profession for five years;

the role of the engineer as a leader in society should be greatly emphasized as the crisis in engineering education hangs on the question of quality, not of quantity.

In the meantime what can the student do for himself? His course of study is pretty well set for him. His days are crowded to the full. How much choice does he have? The first suggestion is that he run a good, thorough survey of his own use of time. Very few students master the art of managing time. A great many students are burdened in mind mainly because they have not learned to plan. Almost everybody can improve in this respect.

What if one finds a spot of time here and there? Aside from recreation, there are two other ways to use this margin: to seek out teachers for conversation or to attend a lecture or read a book about a subject outside the field of engineering. He might do well to choose a student activity with some intellectual base.

Perhaps the most important thing, however, that the student can do for himself is to cultivate the right attitude toward himself and toward his education. The biggest handicap in education today is the lack of initiative and imagination on the part of students themselves. Too much of the drive must be exerted by the teacher.

If students will approach the career of student life as they would approach the first job, achievement would rise sharply. It is a privilege to be a student. The life returns can be enormous, and the resources of the entire university are at his command.

The engineering student stands on shifting sands. His curriculum is changing, his role in society is changing. But he stands on solid ground in that society needs him, and his responsible leadership.

THE ENGINEER:

HIS NEED FOR EDUCATION AS WELL AS TRAINING

by
J. H. Hick,
Associate Professor of Philosophy,
Cornell University

To invite a teacher in the area of the Humanities to comment on the responsibility of the technically trained individual in the modern world is to invite a plea that the technically trained should insist upon being also liberally educated. The basis of this plea is very simple. Being an engineer (like being a physician, financier, physicist, entomologist, educator, etc.) is one of the things that a human being may do; it is a part but not the whole of a man's life. To be a human being remains a more comprehensive, continuous, and in the end a more important occupation than the use of any specific techniques, including those of the engineer. And the exacting training which is required for the special task of engineering should not be allowed entirely to crowd out such preparation as has been found to be helpful for the wider task of being an informed and responsible member of the human community.

A training in engineering consists in the gaining of a certain high-level skill, or rather complex of skills. Preparation for the task of exercising the human prerogatives of freedom and responsibility (a task which we must all undertake, whether equipped for it or not) is called education, and differs from a technical training in that whilst in the latter one is trained *in* some particular field, such as machine design or industrial engineering, in the former one is not educated in anything, but just educated. Education cannot be defined by reference to a body of information learned or an expertise acquired. In distinction from training, education consists in the development of the individual's powers and capacities, and is reflected, not in the number of skills mastered, but in the intellectual growth manifested.

This is not to say that a technical training has no educational value of its own. On the contrary, a disci-

ABOUT THE AUTHOR

Professor John H. Hick, Associate Professor of Philosophy at Cornell University, came to Cornell from England in January, 1956. He was formally educated at Hull, Edinburgh, Oxford, and Cambridge, receiving his Master of Arts Degree at Edinburgh, and his Doctor of Philosophy Degree at Oxford.

Professor Hick has written a book on the nature of religious faith, and has written and delivered several papers of the International Congress of Philosophy. Before coming to Cornell, he was minister of a Presbyterian Church for three years in Belford, Northumberland, England.

At Cornell, Professor Hick has taught a number of philosophy courses. These include a course in Christian Theology, Philosophy 102—a second course in philosophical classics, Philosophy of Religion, and Problems in Philosophy of Religion.

pline in the exact procedures of the Sciences must tend to develop objectivity and a respect for facts; and Cornell is, I think, wise in insisting that students in the Arts must include in their curriculum at least the elementary study of a Science. But although technology is incidentally educational, education is neither its main purpose nor its main result. Technology requires and develops intelligence (as a combination of measurable capacities and aptitudes) rather than culture, which is not commensurable with intelligence and is a product of the individual's participation in the values of his civilization. A certain degree of intelligence is indeed essential if the mind is to be capable of education. But intelligence is not enough. A highly intelligent Ph.D. in a technical field can be, and sometimes is, virtually uneducated. A man might successfully design a skyscraper or a jet bomber, build a thermo-nuclear reactor, plan an efficient production line, or even build up an industry—all achievements requiring a high degree of intelligence and an advanced technical competence—and yet not be, in any significant sense of the terms, an educated or cultured person.

Why does this matter? Why should the technically trained burden themselves with an obligation to be educated, when they are already perhaps over-burdened by the demands of their own technologies? On what grounds is it claimed that culture is important, when a purely technical training can often command twice the salary that an Arts degree makes possible?

The answer lies in the relation between means and ends, and the superior importance of the latter. Technologies are means; they deal in the currency of power; and their value depends upon the ends which they make possible. The present stage of human civilization is one in which there is an abundance of technical skill, but great confusion as to the proper ends to be pursued. Man has today power out of proportion to his wisdom and understanding. What the world desperately lacks is not technical know-how, but moral and spiritual know-what and know-why; not power, but the capacity and disposition to use power wisely. A training in means is not enough; an education concerning ends is also required.

The dangers that come from power unmatched by wisdom are twofold, affecting man's outer and his inner life. Threatening our outer or material life is the peril from force which is not responsibly directed. If mankind launches upon itself the holocaust of nuclear warfare, and regresses through the resulting chaos to a second Dark Age, this will be the achievement of the most technically advanced generation, more successful than any of its predecessors in mastering the natural forces of the Universe. The fatal deficiency will not be in our power but in the ways in which we use our power. There has therefore never been an age when it was so desirable that those who control the forces which man has harnessed should also be responsible human beings. In other words it has never been so necessary that technologists should be educated persons, and not merely the uncritical instruments of industrial and political leaders.

The threat to man's inner life from power unmatched by wisdom is the danger that those who deal with power as technologists may become the servants of their machinery. If a man spends his days in a laboratory or workshop elaborating, inventing or repairing machinery, and is not also vitally related to a wider environment transcending the world of the machine, then he is the slave and not the master of his mechanism. If he lacks an informed concern as to the ends and values which technology can serve, and a sense of responsibility towards his fellows, he is only a blind custodian of a blind god. Power should be regarded as a means and not as an end. But a purely technical training necessarily treats it for practical purposes as an end in itself. Such training should therefore be supplemented by that participation in the higher values of one's civilization which we call education. This will both reveal the true status of power as a means, and will raise, and keep prominent, the question as to what ends are worthy to be pursued.

The effectiveness of education for the right relating of means to ends arises from the character of the educational process. This is not an intellectual development *in vacuo,* unrelated to any subject matter. It involves an expansion of the individual's awareness and understanding of his specifically human environment. To be educated should mean to inhabit this world, not simply as an intelligent animal, successfully earning a living, but as a *human being*—that is to say, as a morally responsible agent with a concern for one's community and a commitment to the welfare of mankind. This concern and commitment provide the material for education, which consists in the appropriation of, and participation in, some aspect of man's culture—his knowledge of his own past, his interpretations of the Universe, his imaginative creations, his speculations, his faiths. These constitute the traditional curriculum within which a Liberal Arts education is found: history, literature, languages, the classics, mathematics, art, philosophy, and the social sciences. Such are, in a familiar formulation, "those subjects which, in the history of human civilization, have distinguished themselves as the means whereby man has come to understand himself and the world in which he lives."

At the present time, under the Five-Year Program (in the development of which Cornell has played a pioneering role), students in the Schools of Civil, Mechanical, Electrical, and Chemical and Metallurgical Engineering spend a portion of their University career in Liberal Arts studies. In theory, the equivalent in school time of one year out of the five is devoted to this extension and deepening of the student's educational background. In practice, however, the system is not quite so favourable as this figure might suggest to a general non-technical education. In the curriculum for the degree of Bachelor of Civil Engineering, for example, if one discounts elementary English as pre-educational, being designed merely to make the student literate, and Public Speaking, as being a technique rather than one of the traditional Humani-

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THE METAPHYSICS OF ENGINEERING

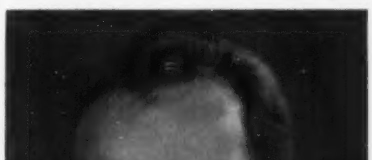
by
Glenn A. Olds,
Director, Cornell United Religious Work

What student these days has not heard, "This is a time of crisis!" Such word is no "news" to a generation bred in the shadow of a depression, two hot wars, and the chill of a continuing cold one. This is a generation that knows that two-thirds of the world goes to bed at night hungry and dies before it is thirty. It remembers, also, that the flowering of the scientific genius of Germany produced a moral Frankenstein, and the moral sentiment of the liberal spirit, a Munich.

Having heard, every student knows in his deeper moments that there is no simple reason for "our crisis." He is rightly suspicious of the neat analyses and dangerous dichotomies: physics versus psychology; the machine versus man; science versus religion; and in educational circles, the technical versus the liberal. The student knows that every "crisis" is, as the Chinese wisely translate the term, a "dangerous opportunity." He knows that our problem in education is not that we have too many engineers and not enough liberal arts students, or vice versa, but that all too frequently the engineer is merely a "measurer" and the liberal arts student merely "liberated" from any meaningful life vocation, rendering them both less than fully human.

Our need, now as always, is for men who know *who* they are, *where* they are, *why* they are, *what* they must do, and *how* to do it. It

ABOUT THE AUTHOR



Dr. Glenn Olds, Director of Cornell United Religious Work, holds degrees from Willamette University, Garret Theological Seminary, Northwestern University, and Yale University. Before coming to Cornell in 1954, Dr. Olds taught at Yale, Depauw, Northwestern, Garrett, and the University of Denver.

As an ordained Methodist Minister, he preached in churches in Oregon, Connecticut, Illinois, Colorado, and Wyoming. He has spoken at colleges and Universities throughout the United States, as well as at numerous Methodist Annual Conferences.

Dr. Olds is author of the book, *The Christian Corrective to the Campus Confusion*, and of numerous articles published in philosophical and religious journals. He is known to Cornellians as a challenging speaker and an effective leader in making Cornell United Religious Work a more meaningful part of the individual student's college life.

is for men interested enough in *meta*-physics to be able to put physics in its proper place, to be able to relate nature and human nature in proper and creative ways. (*Meta*-physics from the Greek means, literally, "after" or "beyond" physics, and is used in a non-philosophical sense in these remarks.)

Every student knows that though man is a child of nature, he is a rebellious child. He comes from her, is bound by her; yet, in another sense, he transcends her, stands over against her. His existence is hyphenated. His life is a bridge between *existence* and *meaning*, the order of nature and the freedom of spirit. He is by nature an *engineer*, son of the oldest art, born not of leisure or the lust for power, but of the necessities of his precarious and wonderful human situation. His is the art of transforming the goods of life into the good life, the understanding of nature into the preservation and perfection of human nature.

Occasionally man is trapped by one or the other—sheer existence or abstract meaning—and surrenders his hyphenated life for a period. He may surrender to nature through the despair of death or finding no higher meaning than the dust, as in various cultural forms of materialism. Or he may reject nature and seek consolation through various forms of abstract meaning, as in various forms of pure idealism. Such abstract idealism is frequently a luxury that rests solidly on the shoulders of others more earthy minded—or bodied!

Our own history in the West suggests that these are false abstractions, swiftly passing. Our heritage from Greek, Hebrew, and Christian sources affirms that man "in reality" is *made to relate*, to engineer nature into the service of the free spirit, to mirror the activity of God in creation, to serve as a bridge between existence and meaning, to translate vision into action, form into fact, power into perfection. To forget this is to cease not only to be an engineer but to be truly human, and makes man into the mirror of his own measuring, a methodical machine, a dull clod, or the image of an abstract god.

It would be presumptive and beyond the scope of this brief statement to trace the philosophy and method for producing such "real men", though nothing short of this should content anyone concerned with the meaning and mission of education in our time. It will perhaps serve this occasion to suggest, not in terms of courses, curriculum, or life objectives, but in terms of motives, habits of mind, and responsibilities, what this might mean to the engineering student today.

The root of engineering, conceived as this basic human art of relating nature and human good, lies far back in time. Akin to the religious spirit (the Latin root for religion means "to bind together"), this root develops in the soil of curiosity, wonder, and the sense of relation. Enriched by reverence before the world's mystery and by hope in the presence of man's power and freedom, this fundamental root of engineering is man's desire not to master but to minister—to minister to human good through the mastery of nature and her goods. The desire to *be* a bridge is the root of the skill to *build* a bridge. Let this root go untended for long, and the fruit begins to wither and rot on the vine. Service gives way to power, power perverts, and the perversion blinds us to our true nature, need, and proper function of our skill.

The dilemma of the contemporary engineering student lies frequently here. Inheritor of a fundamental art long since become a technical skill, he fails to see or tend the soil that serves his skill. Increasingly, then, in order to keep his study alive and his vocation relevant he must find artificial or secondary supports, such as fear of failure, hope for the right contact, professional prestige and material success. In such a climate it is not easy to find, much less keep alive, the sense of service.

Still, the tools of his trade can be the instruments of recovery of the deeper art, his *raison d'etre* as an engineer. The habits of mind that he must cultivate can draw out the sense and import of the earthy soil of curiosity, wonder, and the sense of relation. Curiosity, of itself, can parent weeds of wild-eyed fancy, irresponsible conjecture, and strange superstition. The serious student knows it must be tended, tilled by critical thought and ever widening acquaintance with fact. Wonder, too, may invite escape into a world fabricated only by a wish. It must be domesticated without being destroyed, harnessed to hard-headed analysis of realities and possibilities, made relevant to man's resources and reason as well as his imagination. The sense of relation, root of man's reason, must also be renewed through living contact with other minds and other realms of fact. Reverence before nature's mystery may foster blind piety or unthinking acquiescence, even as hope in man's powers may lead to arrogant pride. Both need the discipline of controlled experiment, the long nights of patient testing that are the lifeblood of the engineer. The engineer's mastery of nature must be matched by humility, to save him from the temptation to master men; concern to serve must be matched by solid skills to make the motive one with deed.

In a world broken into fragments of thought and life, resources and men, the deep desire to relate, at the root of the engineer's practice, needs to be nurtured by the search for fundamental unities, procedures, and principles that is part of his skill. The engineer needs the flexibility to translate from one frame of reference to another, in idea, material, or structure, in order to wean himself from provincialism, the dogma of the particular, or the idolatry of a single frame of reference.

To be sure, this road is dangerous. Discipline, forgetting its root or goal, can become deadly. Habits of mind harden. The servant becomes the master. Cultivation that forgets the soil and seed can uproot and destroy. *Service* and *skill*, *concern* and *competence* belong to-

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THE ENGINEER:

A LONG RANGE VIEW OF HIS WORK

by
G. B. Warren,
Vice President, Turbine Division,
General Electric Co.

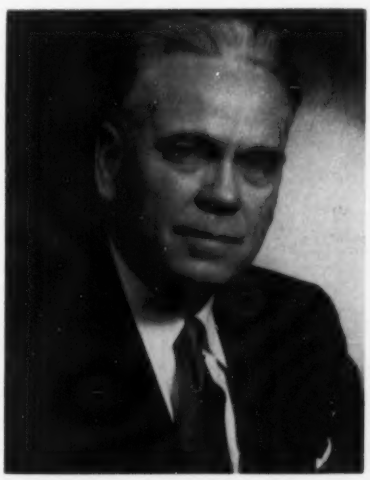
This Christmas my wife and I opened a large package sent to us by our older son and his wife as a Christmas present. The gift turned out to be a very old oil painting, probably by an obscure painter. As we looked at it close up, it seemed to be merely blobs of color without either form, beauty, or meaning. On moving it over to the mantle piece above the fireplace, however, and standing across the room, it came to life as a beautiful seascape looking into the sunset filled with beauty, meaning, and life. The golden sun was reflected on the swells and one could almost hear the surf pounding in the foreground. So it is apt to be with almost anything, particularly one's life work. Let us take an "across the room" look at "engineering" which many of you recently and which I more than forty years ago selected as my life's principal work.

First, what is engineering? Recent editions of Webster's dictionary define it as, "Applied science concerned with utilizing inorganic products of earth, properties of matter, sources of power in nature, and physical forces for supplying human needs in the form of structures, machines, manufactured products, precision instruments, industrial organization, the means of lighting, heating, refrigeration, communication, transportation, sanitation, and public safety and other productive work."

I like to think of engineering more broadly and more simply as the art of applying the results of scientific discoveries to the materials and forces of nature for the service of mankind.

Originally the term was applied to the running of engines, then military engineering came to be recognized. After that and for a while all other kinds of engineering came to be known as civil engineering—which still later was subdivided into our modern usage of

ABOUT THE AUTHOR



Mr. Glenn Warren is Vice President and Consulting Engineer for the Turbine Division of the General Electric Company in Schenectady, New York. He had an early interest in turbines beginning in high school and continuing through his undergraduate engineering training at the University of Wisconsin.

After graduation, Mr. Warren joined the General Electric Company. He rose to Chief Turbine Engineer, and was active in the development of steam turbines for public utilities, naval and aircraft propulsion turbines, and gas turbines for stationary and locomotive use. Several years after GE decentralized into separate operating divisions, Mr. Warren became Vice President of the General Electric Company and General Manager of the Turbine Division.

A member of numerous technical societies, author of 19 published technical papers, and holder of 47 patents, Mr. Warren is recognized as an outstanding authority on turbine design. He was given an honorary degree of Dr. of Science by Union College in 1956. Mr. Warren is also active in community affairs, and has given numerous addresses to religious and educational groups.

civil engineering, then mechanical, electrical, mining, structural, metallurgical, aeronautical, electronic and now many, many more subdivisions—with the end not yet in sight.

In the first place and from the closer look, to one who loves his job engineering is one of the most rewarding vocations one can get into. An old boss of mine, and an outstanding successful engineer who had many outside interests and hobbies, once said to me, "Isn't it a shame that we have to spend so much time on our job, but isn't it a blessing that it is fun," and I know of no better way to put it. To the well-trained and capable engineer his job and the sense of achievement it gives represents some of the most rewarding experiences in life.

Let us, however, take this longer look at engineering by comparing what the world was like in the "pre-engineering" days with what it is like now in the western world where we have the highest development of the art and application of science, engineering and industry—which go together. Let us look in comparison also at what life is like in other parts of the world which are even now living in a great extent in a "pre-engineering way."

Most authorities say that engineering as we know it is but 150 to 175 years old. The graph shows a plot of some data which has been gotten together showing the increase in the average per capita income in the United States of America over the last 450 years, and with some similar more approximate data on countries living in a pre-engineering civilization today. Above the curve are listed a number of very significant world events or movements which were required to lay the foundation for what started about 1775. Some of these are (1) the principles enunciated by Francis Bacon (and Roger Bacon three hundred years earlier), (2) the Renaissance and (3) the Reformation that let men think again, (4) the invention of movable type printing that spread knowledge, (5) Newton's laws of motion which permitted the design of machinery, and other innovations indicated and not shown laid the foundation for the growth of science, engineering, and industry which in turn produced the explosive progress of our economy from 1800 on.

The present low productivity of the many nations still in the pre-engineering stage is also shown by the lines in the bottom right-hand corner.

Now many in looking at this curve will say, but surely the great civilizations which flourished as in Alexandria, Egypt, in Greece and in Rome 2000 years ago or in the capitals of Europe in the 18th century were at a level of productivity higher than shown here. This curve, however, is on the basis of productivity per capita and these city civilizations were great because they were based on slavery or other means of exploitation of labor, and the apparent riches of the few in these cities were distilled out of the frightfully low productivity of the masses by means of military or economic exploitation.

Mr. Crosby Field, an engineer of note, has made a study of this and the following quotations from his recent paper, "The Engineer's Greatest Achievement" in the March 1956 issue of MECHANICAL ENGINEERING, are of interest, pointing out that such exploitation has been largely eliminated by the engineer.

"The hypothesis that no city civilization of any early time existed on any base other than slavery is substantiated by every archaeological find today! Moreover, the higher the degree of civilization, the greater the number of slaves."

• • •

"The Great Pyramid of Cheops required 100,000 slaves for 20 years." (to build)

• • •

"Of course slaves could not marry, but all progeny of a slave, whether by slave or free person, was slave. Slave breeding farms did exist in most ancient cities, but they did not do well. Their operators learned just as did our own negro slave breeders that raising a human being for the market was much more expensive than letting him grow to maturity free, and then kidnapping him. Even when slave breeding did become profitable in peacetime a good war, with its mass kidnapping, would be sure to put it out of business.

"Most of the wars of that time were in reality little better than large kidnapping raids."

• • •

"In Charlemagne's time slavery was not confined to the mines, but in his dominions it was the universal source of labor, even that of Church lands. For example, about the year 796, he appointed the English scholar Alcuin to be Abbot of Tours, a monastery with possessions so vast that its lands were worked by 20,000 slaves."

• • •

". . . the removal of the need for human slavery is in fact his (the engineers) great contribution to the world. How has he accomplished this? By the substitution of cheaper mechanical power for the apparently cheap but relatively more expensive muscle power of the slave."

• • •

"Although many figures have been given, yet they may all be summarized by saying that in the pre-engineer civilizations the *average* number of human slaves per free man varied from one to ten, every American today has the equivalent on an energy basis of 260."

We commonly look upon this increased productivity and call it our increased "standard of living." I fear that in connection with this many people disapprove and see only the increased "gadgetry" of the upper third of the population, the cars, the TV sets, the more luxuriant condition of living, and what they might call the "froth." Instead, the real situation is that never before in the world's history has there been a society in which the income of the lowest workers is as close percentage-wise to the income after taxes of the highest paid official, or politician, or capitalist or boss as in our modern engineering influenced countries.

Never before has there been so little want in per cent, so little suffering from that standpoint. We have new and better hospitals and schools, better working conditions in the factories, more healthful surroundings in the shops and the neighborhoods, a beginning at slum clearance and healthful suburban living with much more to come, the beginning of better salaries for teachers, college professors, ministers, nurses, policemen and military personnel, and for all kinds of public servants.

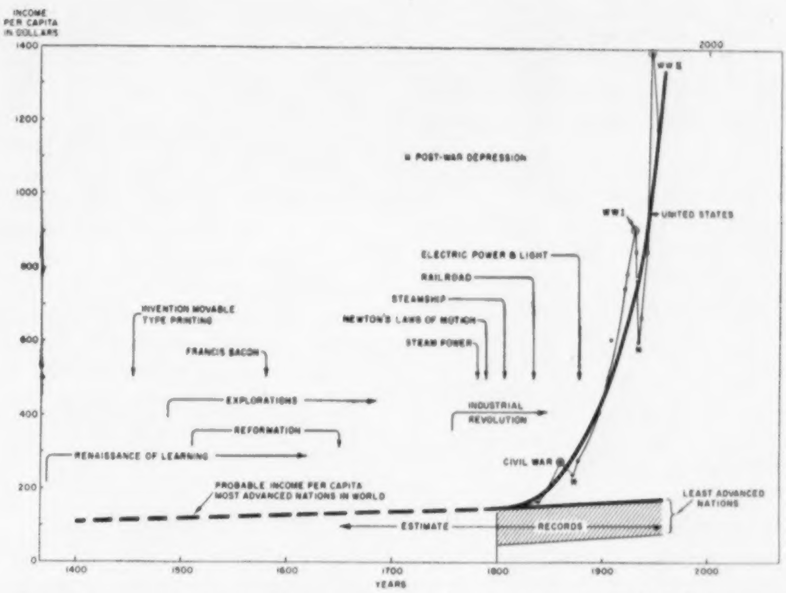


Chart shows an increase in the average per capita income in the United States over the past 450 years. Similar data for countries with a "pre-engineering" civilization is included.

We have electric appliances in the home that have eliminated the servant problem and the low standard of living problems of the servant, and that have given the wife and mother more time for her family, community, and for her cultural development. We have automatic coal mining machines that are upgrading the work of the miner and eliminating his back-breaking toil and making mining the highest paid trade in this country today. Earth is moved by great "bulldozers" that are managed by one man and yet that do the work formerly done by scores of men and animals. Then there are the many machines used to increase the productivity and ease the labor and isolation of the men and women on the farms. We have an ease, facility and speed of transportation of goods and people such as never existed before.

As stated by Crosby Field, slavery has been largely abolished in the world, except under Communism, and because the machine has made human slavery unprofitable. Great laboratories are discovering penicillin, strepteomycin, polio vaccine, and scores of other drugs of equal value with more to come, and industries are being organized to produce these things so prolifically and cheaply that all may have their blessings. These and many more things, not all good, but good on balance, it seems to me, we should think of when we think of high productivity, and in all of this the engineer has played an indispensable role.

Now you will ask, what of the future? We are by no means at the end of this industrial expansion in this country, and much of the rest of the world is just beginning this development. Also, the rapid proliferation of new fields of activity for the engineer, coupled with the increasing depth of understanding of and quantity of engineering work required by all modern technology are creating a demand for engineering services in both quality and quantity that was scarcely dreamed of ten years ago. Whether in peace or in defense of our country and our way of life, for which the services of the engineer are in great demand, the engineer has an important and honored place in life today and will have even more so in the future.

A few years ago the engineer could rightly claim that he was not being properly rewarded for his work. The law of supply and demand has pretty well taken care of that, and today financial rewards are very much improved. We are faced now with an increasing shortage of engineers and scientists. Here again, the law of supply and demand will take care of that. We can see it acting now in the increasing engineering enrollments in the colleges. In the meantime and in the future, one of the highest callings of the young engineer or scientist is that of teaching in high school, college, or university, and one of the urgent obligations of the engineer in practice is to act as an older advisor, teacher and source of inspiration to his younger engineer associates.

Then in view of much of the foregoing, we engineers have still another obligation. Less than 25 per cent of the world's population is now living under the advantages of a modern engineering and industrial standard of productivity and living. The remainder of the world's population is just waking up to the tremendous potentials available to them if they can avail themselves of these advantages and this way of producing goods and services.

It took us 175 years to reach this point. Much of our productivity had to be diverted to tools and capital in order that the engineers and industries could use them in increasing worker productivity and so bring about this result. We can help other countries some by exporting goods and capital tools on credit or by give-away, but the amount of this we can do is infinitesimal in comparison to the need. Like us, these other countries must produce their own tools and capital and goods. In helping them, however, one of the great contributions we can make is in the exportation of scientific, engineering, and management know-how. This we can do by example, by papers published in technical periodicals, by opening our doors and hearts to students from all over the world, and then by some of you exporting yourselves and your services by means of careers in the far corners of the world.

In view of all of these things, it seems to me that for one who is fitted and trained for it, an engineering career is not only a most rewarding personal career, but one for which the world has great need and which offers rare opportunities for service.

HICK

(Continued from Page 30)

ties, there remain twenty-four hours, including twelve free electives, to be used outside the College of Engineering. If the student takes advanced ROTC courses, these will require his twelve elective hours. In this case his acquaintance with the Liberal Arts is confined to two courses in the History of Science and two in Economics. If he does not take the advanced ROTC courses he has his twelve elective hours with which to explore further the realms of human history, literature and thought.

It is not for one who is ignorant of Engineering to say whether a more liberal allowance of time could be allotted to the Arts in an Engineering curriculum, without jeopardising the quality of the technical training provided. But speaking purely from the point of view of the Humanities one must say that the student who expends his elective hours in ROTC can hardly qualify, on the strength of his Cornell curriculum, as an even mildly liberally educated person. Likewise, the student who uses his twelve elective hours within the area of the Arts can hope to receive only the beginning of a liberal education.

It may be that there is no satisfactory solution to this problem. Certainly I am not myself competent to propose a solution. The problem does however remain a real one. In the meantime, Engineering students should be urged by their advisers to take the fullest advantage of the elective system in order to lay the foundations of a liberal education—foundations upon which they may build in later life. Probably, in point of fact, many students look upon the necessity to take Arts courses as merely delaying their careers as engineers. But I return to the thought with which I began. The engineer is also a human being. As well as requiring a training, he deserves an education. And to the extent that he is aware, or can be made aware, of the rich heritage of human culture awaiting his exploration and enjoyment he will be eager to grasp all the educational opportunities available to him.

OLDS

(Continued from Page 32)

gether. Recovery of the roots need not discount the fruits. It only assures us that the fruit will be kept fresh and growing. This is the critical need in our time. From this school in discovery and translation there is no graduation. It alone leads to a larger life.

But cultivation of the sense of service, disciplined through habits of mind, must be finally schooled in responsibility. The engineer is the "rope stretched across the abyss" between human need and nature's abundance. His art is truly sacramental. He may forget this, reject this, or seek to change this, but he cannot cease to *be* this and remain an engineer. All his skill and wisdom focus on this critical relation. He draws his insight from both banks—natural and human—to which he is inescapably related. If his mastery of nature outruns his ministry to human need, he builds a bridge already strained at the center. The range of the world's resources is ringed about by human need in such pathetic urgency that only the blind could miss the prophecy. Nature's resources and human need belong together, and it is the engineer's high calling, indeed, his responsibility, to relate them. His art provides the precarious thread, the dizzying height over the abyss. It bears the weight of the future. If he fails, his failure is not merely a matter of personal or professional profit. It is *meta-physical!* For to fail here is to fail not in physics but in what comes before and goes beyond physics—the human venture. It is to fail in the oldest art, the art of transforming existence into meaning, life into the good life, nature into something more divine.

The deeper meaning of engineering cannot be grasped by a passive perception or by shallow sense. There is nothing shallow about engineering. There is something ultimately profound about the roots and fruits of this basic human art. Indeed, one might say that only this deeper meaning makes the vocation of engineering adequate to the necessities of our time and the possibilities and responsibilities of our human situation.

CLAD STEELS

(Continued from Page 14)

In recent years, the quantities of chemicals produced by the industry have increased to make their transportation by tankship both practical and economical. Nickel-clad steel was used in the tanks to handle caustic in the "Marine Dow-Chem". In another application, the "Chemical Transporter", Type 304L stainless-clad was selected for the tanks to handle formaldehyde and acetic acid.

Even the wine industry is getting into tankship transportation of their products. To the salvaged stern end of a tanker which broke in two is being added a new forward section containing Type 316L clad steel tanks. This tanker will carry wine from the West Coast for distribution in the East.

An example of the salt water resistance of Monel-clad is the swimming pool on the super liner, "S.S. United States". Weight savings and freedom from costly maintenance were made possible with Monel-clad construction over the conventional tile-lined type of pool.

Another sea water application of Monel-clad is its use in the Early Warning Radar Platforms, known as Texas Towers, located along the New England coast. These huge triangular-shaped platforms rest on three caissons ten feet in diameter. Carbon steel with cathodic protection is used for the totally immersed sections of the caissons, but thirty-five feet of Monel-clad were used for the sections of each caisson in the tidal and splash areas where the metal is alternately exposed to salt water and sea air.

An example where cooperation between industry and our universities proved fruitful can be found in the application of clad to bridge bearing plates. Type 310 stainless-clad steel was selected because of its physical properties and atmospheric corrosion resistance. After exhaustive testing at the Sibley School of Mechanical Engineering, Cornell University, the material has been used in a number of bridges, among these being the Walt Whitman Bridge across the Delaware River between Philadelphia and Gloucester, N.J., now under construction.

Progress and Diversification

AT PITTSBURGH PLATE GLASS COMPANY

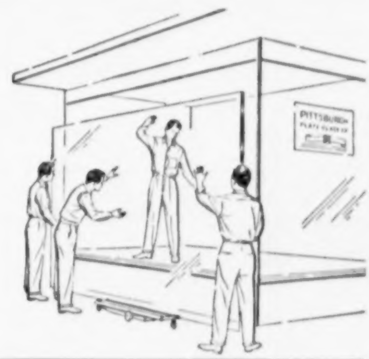
The year 1956 was a good one for the Pittsburgh Plate Glass Company—and the Company looks confidently to 1957 as another year of progress in its widely diversified fields of operations.

PAINTS & PLASTICS

Many new products, including Duracron acrylic enamel were introduced in 1956 for both consumer and industrial use. Additional capacity is being planned in 1957 for Selectron Plastics, a series of versatile thermosetting resins.

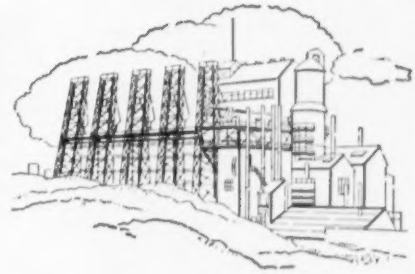
GLASS

Window and plate glass plants operated at capacity in 1956. Partial production was started at Pittsburgh Plate's new Cumberland, Md., plate glass plant.



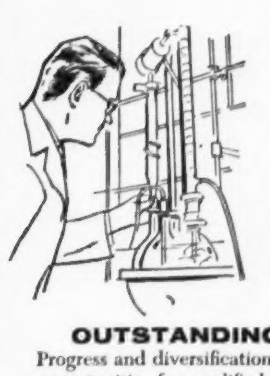
CHEMICALS

During 1956, wholly-owned subsidiary, Columbia-Southern Chemical Corporation, began operating a titanium tetrachloride plant at Natrium, W. Va. A new trichlorethylene plant was completed at Barberton, Ohio.



FIBER GLASS

Production facilities for both Superfine and textile fibers were expanded during 1956 at the Company's Shelbyville, Indiana plant.



RESEARCH & DEVELOPMENT

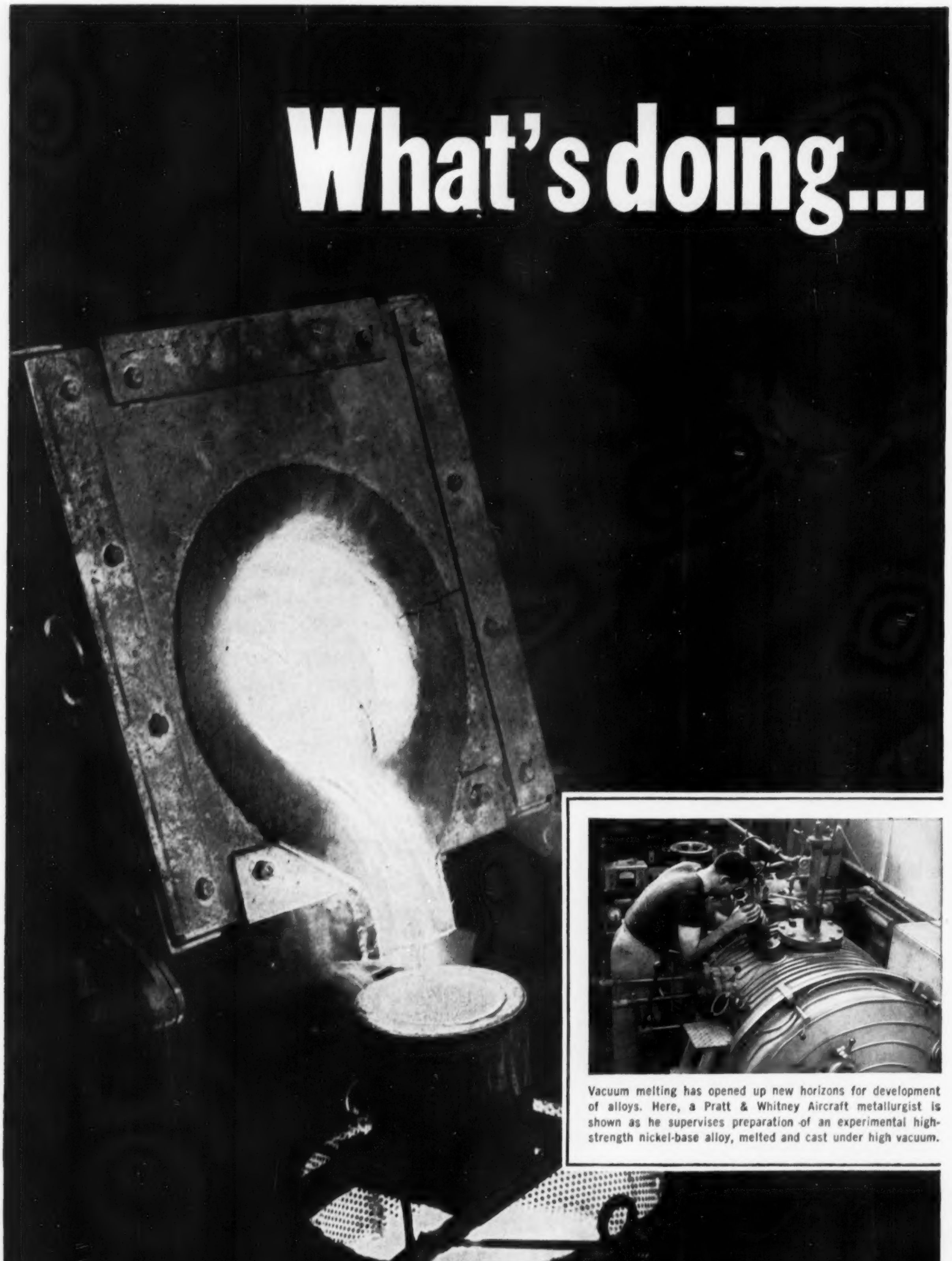
Expanded facilities in new and modern laboratories, plus growing budgets, assure new and improved glass, paint, chemical and other products. New techniques and equipment, perfected by research and development teams, are helping speed production. These forward-looking programs not only mean continued progress at Pittsburgh Plate and Columbia-Southern, but also better products and service for the customer.

OUTSTANDING CAREER OPPORTUNITIES

Progress and diversification at Pittsburgh Plate is providing excellent career opportunities for qualified graduates. If you are interested in putting your talents and initiative to work where they will be respected and rewarded, by all means look into your career possibilities with Pittsburgh Plate Glass Company. Write to General Personnel Director, One Gateway Center, Pittsburgh 22, Pa.

PAINTS • GLASS • CHEMICALS • BRUSHES • PLASTICS • FIBER GLASS

PITTSBURGH PLATE GLASS COMPANY



Vacuum melting has opened up new horizons for development of alloys. Here, a Pratt & Whitney Aircraft metallurgist is shown as he supervises preparation of an experimental high-strength nickel-base alloy, melted and cast under high vacuum.

Induction melted heat of high-temperature alloy being poured in P & W A's experimental foundry. Molten metal is strained into large water tank, forming metal shot which is remelted and cast into test specimens and experimental parts. Development and evaluation of improved high-temperature alloys for advanced jet engines is one of the challenges facing metallurgists at P & W A.

at Pratt & Whitney Aircraft in the field of Materials Engineering

The development of more advanced, far more powerful aircraft engines depends to a high degree on the development of new and improved materials and methods of processing them. Such materials and methods, of course, are particularly important in the nuclear field.

At Pratt & Whitney Aircraft, the physical, metallurgical, chemical and mechanical properties of each new material are studied in minute detail, compared with properties of known materials, then carefully analyzed and evaluated according to their potential usefulness in aircraft engine application.

The nuclear physics of reactor materials as well as penetration and effects of radiation on matter are important aspects of the nuclear reactor program now under way at P & W A. Stress analysis by strain gage and X-ray diffraction is another notable phase of investigation.

In the metallurgical field, materials work involves studies of corrosion resistance, high-temperature mechanical and physical properties of metals and alloys, and fabrication techniques.

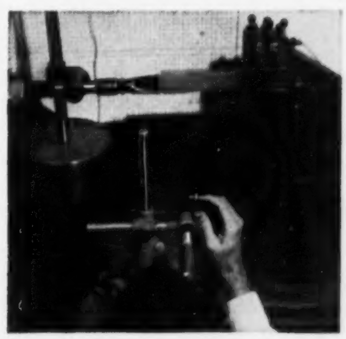
Mechanical-testing work delves into design and supervision of test equipment to evaluate fatigue, wear, and elevated-temperature strength of materials. It also involves determination of the influence of part design on these properties.

In the field of chemistry, investigations are made of fuels, high-temperature lubricants, elastomeric compounds, electro-chemical and organic coatings. Inorganic substances, too, must be prepared and their properties determined.

While materials engineering assignments, themselves, involve different types of engineering talent, the field is only one of a broadly diversified engineering program at Pratt & Whitney Aircraft. That program — with other far-reaching activities in the fields of mechanical design, aerodynamics, combustion and instrumentation — spells out a gratifying future for many of today's engineering students.

Engineer measures residual stress in a compressor blade non-destructively, using X-ray diffraction. Stress analysis plays important part in developing advanced aircraft engine designs.

The important effects of gases on the properties of metals have been increasingly recognized. Pratt & Whitney chemists are shown setting up apparatus to determine gas content of materials such as titanium alloys.



P & W A engineer uses air jet to vibrate compressor blade at its natural frequency, measuring amplitude with a cathetometer. Similar fatigue tests use electromagnetic excitation.

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GOVERNMENT FLOOD CONTROL

by

Martin Sahn, CE '58

The United States Government, through its agency the Army Corps of Engineers, is at present engaged in extensive flood control activities. The Corps has gained its responsibility in this field partly by federal law and partly by tradition.

The law states explicitly that the functions of the federal government shall include the examination, survey, improvement and maintenance of rivers, harbors and other waterways for navigation and allied purposes. The first engineers in government employ were West Point trained; consequently, it was only logical to call on the army to control its engineering activities. On March 6, 1802 Congress created the Corps of Engineers, which was officially empowered to develop streams for navigation by an act passed in 1824. Since then the Corps has played a major part in the subsequent development of inland waterways.

Flood control activities are in many ways tied in with those of inland waterways; therefore the Corps, because of experience gained in past activities, was given the added responsibility of flood control as well as navigation. Its activities at present consist mainly of design of structures and inspection of construction; the actual construction of the projects is left to private contractors, on the basis of competitive bidding.

In the design of a flood control project, five points are considered: hydrology, geology, hydraulic design, structural design, and costs.

Hydrology

Hydrology with respect to designing a flood control development is the study of rates of precipitation and runoff and their geographical distribution with respect to natural drainage features of the ground. A common approach to the problem is the consideration of what is known as a design flood. This concept is closely linked with probability analysis. If, for instance, a project is designed for a 50-year flood, that project is likely to be inadequate to handle the flow only once in 50 years. This does not

A length of completed flood retaining walls.

A view showing the stages of construction in a tight industrial area. Note the method of stream diversion, with sheet piling running down the center of construction.

Looking upstream at a newly completed parabolic drop structure.

Cross-section of a completed wall and concrete slab channel bottom.

mean that it could not be overtopped in a period less than the design period, but only that past studies have indicated that a flow equal to or greater than the design flow occurs on the average, once in 50 years. To partially overcome the uncertainty of this concept, the Corps will often specify that the project is to provide protection against a flood 50 per cent greater than the largest flood on record.

The measure of the size of a flood is obtained by a study of hydrographs of the runoffs in the watersheds. A hydrograph is a plot of rate of flow in a particular channel versus time. Besides learning the instantaneous rates of flow, the total quantity of water handled can be estimated by graphical integration. The shape of the curve will vary with the particular stream, the rainfall intensity, and the duration of the storm. It will also be affected by factors influencing run off into the stream such as previous saturation of the soil at that time and the extent of vegetation in that area.

Geology

Of increasing importance in the scheme of design is consideration of geologic conditions in the area. Studies of the effects of glaciation, for instance, upon the formations in the New England area afford clues to the effects of the project upon established drainage patterns. This concept is encompassed in regional surveys, which are performed for the most part by the United States Geologic Survey.

Foundation studies along the job site are necessary because of the concrete structures to be erected there. The settlement of these structures and the seepage around them must be held to within certain limits, if they are to be effective. These investigations are carried out by the Corps, using drill holes and test pits to satisfactory depths. The material taken in these operations is analyzed in an independent commercial laboratory under contract to the government. Important data gathered here consist of grain-size distribution, load-deformation and compaction curves and permeability to determine the intensity of soil loading permitted and the field procedure for compacting the soil to the desired density.

The Corps also carries on a preliminary survey to determine the location of the necessary materials of construction. In many cases, areas will have to be built up with soil brought in from borrow pits and it is necessary to locate these. Also, certain types of construction require the placing of riprap, or large stones which lend stability against current erosion of the channel bottom. The practicability of finding such stone must be ascertained, or the design will require alteration to other forms, possibly more expensive than the original design. The availability of such materials as aggregate and sand for concrete and clap for levee cores must also be considered.

Hydraulic Design

The study of hydraulics is both theoretical and empirical. In the hydraulic design of the various structures, model studies are used in conjunction with analytical design approaches. In model studies it is not necessary to reproduce all of the details found in the finished structure, but only those which are under consideration at the time. This is fortunate, for a complete analysis would require a full-scale model, an obvious impossibility. Therefore, the model bears only incidental physical resemblance to the structural shape of the finished design.

In open-channel flow the criterion to be satisfied in the construction of the model is Froude's Law of Similitude. A dimensionless parameter, V^2/lg, is defined, where, v = velocity of flow, g = gravitational acceleration, and l = a linear dimension which can be related to the scale between the model and the finished structure. If the ratio between the Froude number of the model and of the prototype is unity the gravitational flow properties of the water in the model will be similar to those in the prototype. In general, the larger the scale of the model, the more accurate the measurements of velocity, depth of flow, etc. However, the scale is kept down by limitations in space in the laboratory and amount of water

available to the laboratory. In the final analysis the model will develop such features of the design as superelevation of the channel walls, crest shapes of weirs and dams, stilling basins, channel alignment, treatment of intakes and outlets, and determination of special head losses. It will serve to confirm initial assumptions, provide whatever empirical coefficients are required, and introduce minor modifications necessary for an efficient and economical design.

In the actual design of a project the Corps works with certain minimum specifications for safe flow. For instance, the freeboard, or distance from the top of the wall to the maximum water surface must be at least 3 feet. A value for roughness, or friction factor for both concrete and riprap is assumed, taking past experience into account. In order to provide the least trouble from dynamic effects of the water acting against the walls, all curves in the channel are superelevated, the superelevation being reduced to zero uniformly along a spiral connecting the curve with the succeeding straight portion.

Structural Design

The vertical walls and channel-bottom slabs of stilling basins are generally designed as a U shaped statically indeterminate structure, the slab being considered as a beam on an elastic foundation, with equal concentrated forces and moments on both ends. Flood walls are designed in the ordinary manner as a retaining wall with more or less saturation of the backfill. The four load cases considered are those providing maximum effect on stability these being:

Case 1. With the channel full to the top of the wall the landside fill is considered submerged to the top of the wall. The resultant force acting on the wall must fall inside the one-fourth point of the base.

Case 2. With the channel empty, the landside fill is considered submerged below the wall drain and saturated above the drain. A wind load of 30 pounds per square foot is considered acting on the landside of the wall. Uplift and positive earth pressures are considered acting on the footing of the wall.

Case 3. With the channel water

level to within 3 feet of the top of the wall and other forces as in Case 1, the resultant force must fall inside the one-third point of the base. Case 4. For the condition of erection, the wall is assumed as free-standing with a 30 pound per square foot wind load on the full height of the wall above the footing.

Conditions such as these are also considered in the design of bridge abutments and earth retaining walls, but these will not be enumerated since they only represent special cases of flood walls.

Costs

After the designs, both structural and hydraulic, have been worked out, it is the Corps' responsibility to prepare an estimate of the total cost of the project. Some items, such as pumping stations, are estimated on a lump-sum basis, while others, such as concrete and earthwork, are figured on the basis of unit price. The government engineers' estimate is extremely important in these projects, because the low bidder must also be below the government estimate or the contract will not be awarded.

The total bid, as computed from the quantities taken from the plans may be considerably in error, due to errors in working out the quantities. Land to be excavated may, for instance, have been used as a waste area for other excavations, between the time the survey was made and the actual commencement of the job. It is also conceivable that the area could have been used as a borrow pit, whereupon the actual excavation required would be less than the estimated value. It is advantageous to include in the contract, therefore, a provision for renegotiation of the unit prices, should an error of, say 25 per cent in either direction be discovered during the course of the job.

It must be realized that the analyses presented here are done by many people and a high degree of teamwork and chain-of-command are required. The various computations are embodied in a design memorandum, from which the plans and specifications for the job are drawn up. These provide the basis for the actual construction work to be done.

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"And remember, these engineering opportunities will result in personal satisfaction as well as high returns in salary and security. So between you and me, I'd advise you to consider seriously the aircraft industry as you plan your career."

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TECHNIBRIEFS

UNUSUAL GAMMA IRRADIATION FACILITY IN OPERATION

A new gamma irradiation unit has recently been placed in operation by the Radioisotope Department of the Operations Division at Oak Ridge National Laboratory, Oak Ridge, Tennessee. This new unit makes space available in a subsurface Cobalt-60 storage installation for irradiation of materials in an intense gamma field. One feature of the new unit is that samples can be irradiated in air rather than under water, as is done with many gamma irradiation devices now in operation.

Cobalt-60 decays with a half-life of 5.3 years. This new facility is designed to utilize the radiation energy from Cobalt-60 slugs awaiting shipment to customers. Under normal storage procedure the benefit of this radiation would otherwise be lost.

Materials to be irradiated are placed in a 10⅛ in. by 10⅛ in. by 12 in. space at the bottom of a 5½ ft. long concrete shielding plug. Access to the space is through a maximum clear opening of 8½ in. by 8½ in. cross-section. Once samples have been inserted in the compartment at the base of this plug it is lowered into the unit and these samples are exposed to the intense radiation field. Two tubes are provided in the plug for leads to instruments in the irradiation zone.

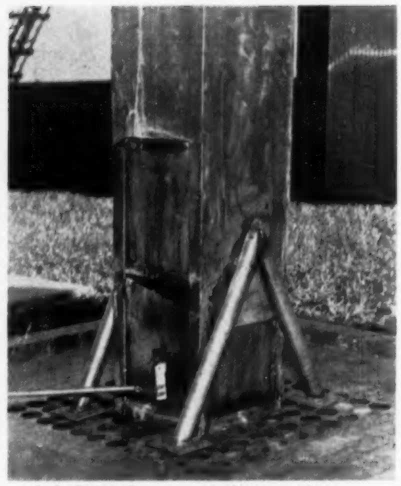
The Cobalt-60 slugs are stored in ninety-two stainless steel tubes arranged in a square pattern surrounding the irradiation chamber. The entire unit is below ground, with a top shield composed of high density concrete and lead. Removal of the heat generated by absorption of radiation in the tubes, shield, and samples being irradiated is accomplished by an air stream flowing through the plenum around the tubes. It is estimated that almost 5,000 watts, or enough to heat two rooms of an average house, will be generated by the radiation heating at a loading of 300,000 curies.

A new application of closed-circuit television provides immediate comparative data of chemical activity within live normal and cancer cells. This new technique, made possible by a developmental RCA ultraviolet-sensitive TV camera tube, is undergoing experimental examination at the National Institutes of Health, Bethesda, Maryland. The National Institutes of Health is the principal research arm of the United States Public Health Service. It embraces seven research institutes, each devoted to specific medical studies, and a Clinical Center which provides patient care for the various institutes.

The RCA ultraviolet closed-circuit TV system makes it possible to obtain quick and accurate measurements of ultraviolet absorption in healthy and abnormal cells. The ultraviolet TV camera tube sees more than the eye can discern when living cells are illuminated with visible light. The direct oscillographic analysis and record of any part of the object-image provides immediate comparative data.

Ultraviolet rays are absorbed in specific and measurable quantities by different chemicals. This characteristic enables the medical researcher to: a) identify the nature and scope of several cellular chemical substances by exposing the cell to ultraviolet light and measuring the absorption ratio; b) introduce foreign chemicals and study their reaction with the cell's normal chemicals, and c) by ultraviolet exposure, to maintain serial studies of disease-suspected cells and tissues and detect and identify chemical changes which may develop.

In the new installation, the ultraviolet absorption image, viewed by the TV camera through a microscope, is converted to an electronic signal by the ultraviolet camera tube. The signal is amplified and then viewed on the screen of the TV monitor, a few feet away. Any one of the 525 horizontal scanning lines can be selected and analyzed by a special oscilloscope, which produces on its cathode ray tube, in two ordinates, a tracing of the absorption characteristics of the specimen.



Cobalt-60 Gamma Radiation Unit.

The ultraviolet television-microscope-oscillographic system has proven of value in studies of living cellular material and possesses definite advantages over other available techniques. The shortened exposure to the narrow bands of ultraviolet reduces cell damage and avoids artificial absorption changes. Direct observation facilitates rapid search of large numbers of cells and other material, and provides better selection of desirable specimens for oscillographic and other studies.

The overall ultraviolet equipment chain, includes an ultraviolet light source, a high-power microscope, the broadcast TV camera with ultraviolet camera tube, a monitor, an oscilloscope, and various motion picture cameras for filming images on both the TV monitor and the oscilloscope.

In operation, the ultraviolet light source is focused on the specimen under the microscope. The Television camera is mounted so that it "peers" through the eye-piece of the microscope. Sensitive to ultraviolet, it "sees" and transmits to the monitor an image of the cell and the action and reaction of its ultraviolet-absorbing chemicals, both those normal to the cell and those induced artificially or by disease.

In its present stage of experimentation the ultraviolet television-microscope system must be considered as a developmental technique, but one which holds important implications for future medical research. It offers significant possibilities also as an important diagnostic medium, for rapid determination of the nature of a diseased cell by direct

ultraviolet TV observation and measurement of the rate, scope, and shape of abnormal chemical changes.

"Point probe microanalysis," a new metallurgical research technique, permits analysis of steel-specimen areas 10,000 times smaller than is possible by any other method. The new technique was conceived in France about six years ago and is now being developed and refined by scientists at U. S. Steel's Research Center in Monroeville, Pennsylvania.

The point probe method of analysis involves the use of an electron microscope containing a focused electron beam to excite X-ray emission from a region as small as a few microns in diameter. The characteristic X-rays emitted are then analyzed by a crystal spectrometer.

This method has wide application in metallurgy for study of inter-granular corrosion, analysis of segregation of alloying elements among the metallic phases and along metallic grain boundaries, measurement of inter-diffusion during welding and plating, and for determining the composition of fine precipitate particles.

The basic instrument being studied and modified is a vertical, 7½-foot electron microscope with a 4-foot electron column. The steel samples to be studied are placed in a specimen chamber through a door in the base of this column, and a vacuum is created by a standard oil-diffusion pump. An optical binocular microscope and a moveable mechanical stage permit the operator to make a visual adjustment of the specimen under the beam.

The beam is generated by an electron gun which accelerates electrons through approximately 30,000 volts. It is focused by three electrical lenses. The electron-beam cross-over point formed by the objective lens is focused by the repeater lens on the surface of the steel sample.

The focused beam strikes a selected area of the specimen's surface, causing X-ray emission. The X-ray beam is then analyzed to determine its component wave lengths by reflection from a lithium-fluoride crystal. Each chemical ele-

(Continued on Page 63)

GRADUATING ELECTRICAL ENGINEERS

1. Lawrence D. Phillips; 2. John T. Martin; 3. Paul H. DeGroat; 4. Arthur Burns; 5. William A. Fietz; 6. William R. Dockwiller; 7. Jay C. H. Hsu; 8. Milton Pelovitz; 9. John Theloudis; 10. Norman Carpenter; 11. Ralph J. Vichill; 12. Lee A. MacKenzie; 13. William J. Hudson, Jr.; 14. Herschel H. Loomis, Jr.; 15. Peter November; 16. Robert Christensen; 17. George S. Durland; 18. John A. Durschinger; 19. Donald W. Exner, Jr.; 20. Richard A. Craft; 21. Richard W. Knoeller; 22. David B. Borkum; 23. Richard F. Hildreth; 24. Marvin Kaplan; 25. Henry Wolfson; 26. John H. I. Morse, 27. Richard L. Bennett; 28. Ismet Turkekul; 29. George Wiltsey; 30. John G. Simek; 31. Ronald N. Yeaple; 32. Robert Whitner; 33. John H. Sachleben; 34. Ralph N. Seymour; 35. Daniel Chernoff; 36. Gerald Dulin; 37. Kenneth Dodge; 38. Burlye B. Pouncey, Jr.; 39. Martin P. Pope; 40. Peter L. Todd; 41. David Perlman; 42. James D. Strickler; 43. Jack Shirman; 44. Sezai Ikiz; 45. Robert S. Gale; 46. Richard A. Brockelman; 47. Max Mattes.

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1. Bennett Brown; 2. Paul F. Snare; 3. Jerome Quinn; 4. Bradford H. Spring; 5. Donald T. Secor, Jr.; 6. James L. Francis; 7. Donald W. Graves; 8. Angelos Cocconis; 9. Stuart G. MacDonald; 10. Douglas H. Merkle; 11. Paul A. Jenkins; 12. Michael D. Nadler; 13. John T. Sills; 14. George L. Schofield, Jr.; 15. Eric S. Yueh; 16. John P. Rawlins; 17. Louis H. Barkhausen; 18. William R. Lang; 19. Stuart L. Jacobson; 20. James T. Embser; 21. Donald R. Wintringer; 22. Leonard A. Pisnoy; 23. Orlando E. Lusi; 24. John K. Holton; 25. Burton W. Melcher II; 26. H. J. Rhodes; 27. John Merkle; 28. Andrew F. Dywan; 29. Ronald L. Swan; 30. Eugene C. Smith.

CORNELL SOCIETY OF ENGINEERS

Walter L. Hardy

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates, and former students and to establish closer relationship between the college and the alumni."

President's Message . . . THE NEXT STEP

Any successful company is always thinking in terms of at least five to ten years hence. In fact, many of the larger companies have "idea men" or "brainstormers" working continuously in the area of the present plus 5 years to the present plus 25 years. Many of today's products are obsolete on the production line, such as, aircraft, computers and atomic power plants. The successful manager of a company, or any division of a company, must also be planning for the future in terms of new products, production improvement, cost reduction, improved human relations. The individual, as sole proprietor and manager of his life and future, similarly must be planning ahead and preparing himself for where he will want to be five and ten years from now. There is no substitute which will insure personal success (not necessarily measured in dollars) and satisfaction.

Your next step—for most of you, your first or second job—should be planned as carefully as a military leader plans a campaign. You are in a unique position at this time in that most applicants can practically name the company with whom they would like to be associated and the position they would like to hold, consistent with their qualifications and experience. Select that company and don't worry that another is offering more money.

Secondly, choose the particular field of activity which potentially satisfies and pleases you the most. If you are a civil engineer and like to design bridges, then design bridges; if a chemical engineer interested in plastics, then by all means go into plastics; if a mechanical engineer interested in automotive engines, then choose automotive engines. Don't be swayed by better offers. There is no sadder, more unfortunate individual than the one struggling away day after day on the design of sanitary equipment, when in his heart and soul he would rather be a test engineer on a supersonic jet airplane. The fact that the former job offered twice as much money doesn't mean a thing.

If you have a career in mind, forget location. Unless there is a personal, compelling reason which requires that you remain in one locale, then let opportunity five or ten years from now dictate your choice. When given the chance, you will be surprised on how adaptable you and your family can be to new circumstances and new friends. I have seen many a career ruined because of arbitrary inflexibility on this point.

The question of the large company vs the small company as your employer is a moot one. Much can be said for and against both. Personally, I feel that the large company offers greater security, while the smaller company offers greater challenge and variety. Actually a good engineer, with a well prepared plan for his personal progress, can do well in both large and small companies.

Keep your plan flexible to take advantage of opportunities as they present themselves. However be sufficiently firm in your program by carefully scrutinizing each opportunity, lest the diversion prove an unfortunate one over the long run.

Walter L. Hardy

ALUMNI ENGINEERS

Martin Richmond, AEME '48, has been promoted to Production Manager of the Radio and Television Division at Emerson Radio and Phonograph Corporation. Mr. Richmond has been associated with Emerson since 1949. In 1952, he became Chief Time Study Engineer; in 1955, he was appointed Chief Methods and Standards Engineer; and in 1956, he was made staff assistant to the vice-president in charge of Manufacturing and Engineering.

Currently, he is active in the American Institute of Industrial Engineers and has written articles on automation, flow planning, and has lectured on these subjects before the AMA and other professional societies.

John T. Parrett, ME '44, recently opened an office in Benton Harbor, Michigan as a consulting engineer, specializing in testing, designing, development work, and methods studies. After graduating from Cornell, Mr. Parrett served as an engineering officer in the Navy for three years, then was employed with the Raymond Concrete Pile Co. in New York City for six years. Following this he did work on a speed reducing mechanism, without the conventional gear train system, for which he holds several patents.

William B. Corydon, BS in Chem '44, BChemE '47, has been appointed head of the Phenol Production Department at Bakelite Company's Marietta, Ohio plant. Since joining the Bakelite Company, Mr. Corydon has held the position of Technical Trainee, has been assigned to various technical projects, and has been Department Head of the Phenol Department since 1954. Mr. Corydon is Chairman-Elect of the Upper Ohio Section of the American Chemical Society and is a member of the Marietta Executive Club.

William Buxbaum, CE '43, recently opened his own office in New York and will specialize in constructing and developing real estate in and around New York City.

Paul M. Brister

Paul M. Brister, ME '36, has been appointed manager of the Engineering Design Section of The Babcock & Wilcox Company's Manufacturing Engineering Department.

Mr. Brister was made chief of Staff Engineering in 1953, and Engineering Department coordinator one year later.

Mr. Brister is a member of the Cornell Society of Engineers, the Cornell Club of New York, ASME and ASTM. He has been active on several subcommittees of the ASME boiler and pressure vessel committee, and on the joint ASTM-ASME committee on effect of temperature on the properties of metals. He is chairman of the steam power panel of this committee.

Donald A. Raunick, BEE '48, has been promoted to Department Manager of the IBM Product Development Laboratory at Poughkeepsie, N.Y. Prior to this promotion he was in charge of the Department of Engineering Information and Technical Publications. Since joining IBM Mr. Raunick has worked on the Type 701 electronic computer, Project High, and on laboratory publications and engineering displays.

Peter Winokur, Jr., EE '43, was granted a patent recently as co-inventor of a system to handle grocery carts in supermarkets.

Fred M. Gillies '18, was recently named chairman and chief executive officer of the board of directors of the Acme Steel Co.

Colonel Paul H. Symbol '48, is presently assigned to the Pentagon in charge of staff supervision for the planning and constructing of homes in connection with the Army's Guided Missile Program.

George Marchev, AEME, merged two electronics companies into the Gordos Corporation, makers of mercury switches. His partners include fellow Cornellians Bill Flint, Lou Mead, Sam Arnold, and Jack Whittenrose.

Sidney L. Luce, CE '35, who has been Managing Director of Chicago Bridge Limited in London since December, 1954 has been appointed District Manager of the Philadelphia Sales Office.

Pietro Belluschi, CE, also attended the University of Rome. He is dean of the school of architecture and planning at Massachusetts Institute of Technology. He is a fellow of both the American Institute of Architects and the American Academy of Arts & Sciences; is a life member of the National Institute of Arts & Letters. Membership in other societies include the advisory committee on architecture, Museum of Modern Art; board of trustees, American Federation of Arst; the commission on architecture, Dept. of Worship & the Arts, National Council of Churches of Christ in the USA.

Sherman R. Knapp has been elected a director of Emhart Manufacturing Co., Hartford, Conn. Sherm, who is president of Connecticut Light & Power Co. thereby adds another honor to his long list of directorships. He also serves as a trustee of Connecticut Bank & Trust Co., Connecticut College, Connecticut Public Expenditure Council, and is a vice-president and director of the Yankee Atomic Electric Co. and president of the Electric Council of New England.

TECHNIBRIEFS

(Continued from Page 53)

Type "R" Pfaudler reactor, utilizing glassed-steel construction.

sively in other industries such as plastics and synthetic rubber.

As with all things, glass in itself does have certain limitations, the most outstanding of which are fragility and thermal shock susceptibility. When the process of applying glass to steel was perfected, the chemist truly had a container with the corrosion resistance of glass plus the working strength and protection of steel. The diagram tells us some interesting information about glassed steel products. In one case a magnified (250 X) cross-section of a glassed steel plate showing powerful mechanical gripping which locks Pfaudler glass to steel (dark area is glass, lighter area is steel). Figure two is a cut-away picture of a type "R" Pfaudler reactor, a one-piece, all-welded unit, a typical application of glassed steel.

At the annual convention of the Association of American Soap & Glycerine Producers, Inc., held in New York on Jan. 25, 1957, several of the problems associated with synthetic detergents in sewerage and water treatment were reviewed.

The situation related to detergents in sewage and water treatment, led the AAS&GP to conclude that alkylbenzene sulfonate in concentrations now present in sewage does not affect bacterial life nor otherwise significantly affect efficiency of operation of a sewage plant; the problem in this area resolves itself primarily to one of frothing and methods are being developed to cope with it.

It is nonetheless apparent that ABS in raw sewage is not completely eliminated by existing conventional sewage treatment and some proportion goes off in its original or partially degraded form through the effluent. There are indications that by control of operations in a sewage plant greater removal of ABS can be achieved in the course of sewage treatment. At this stage, however, there is little promise that specialized strains of bacteria capable of completely degrading ABS can be made to subsist in sufficient concentrations in a sewage plant to be effective.

In relation to phosphates, on which attention has been focused on their possible interference in water treating operations, accumulating evidence points to the fact that the possible offenders (polyphosphates) do not find their way in sufficient concentrations into raw waters to pose a real problem.

ment in the sample emits an X-ray of characteristic wave length. The concentration of the element determines the intensity of that wavelength component. At present the instrument is able to detect all elements with atomic number equal to 22 (titanium) or higher.

The X-ray intensity at each wave length is measured by a geiger or proportional counter. The signal is amplified through a vacuum-tube arrangement to activate a pen on a graph, the X-axis of the graph indicating the wave length and the Y-axis charting intensity. Finally, the technician can analyze these data and translate them into usable form.

Glassed steel equipment is one of the most versatile materials of construction of process equipment. Normally used in the chemical industry to combat corrosion, glassed steel equipment is also used exten-

Ultraviolet Television-Microscope-Oscillographic System as used in studies of living cellular material.

COLLEGE NEWS

PROFESSOR FRENCH

A Cornell educator was named to the group of 20 top farm leaders who will help America's farmers keep pace with the age of advanced mechanization.

Named to the advisory committee of the new Thor Research Center for Better Farm Living was Prof. Orval C. French.

Professor French is head of the agricultural engineering department in the New York State College of Agriculture. He joined the Cornell faculty in 1947 after 16 years on the agricultural college staff at the University of California. A native of Kansas, he received undergraduate and graduate degrees from Kansas State College at Manhattan.

The distinguished group will guide the Thor Research Center in its nationwide "Operation Farm Improvement" program to increase operating efficiency and living comfort through better planning and use of the farm shop.

Secretary of Agriculture Ezra Taft Benson last fall dedicated the non-profit center at Marengo, Illinois, which represents the first organized effort to help the nation's farmers offset their heavy dependence on farm production machinery with modern methods, materials and tools for equipment maintenance and home improvement.

GUIDED MISSILES

"Guided missiles undergo intense environmental stresses in flight that must be simulated in the laboratory before unerring operation can be expected," stated Mr. David Walker during his address at the February meeting of the Cornell student branch of the Society of Automotive Engineers.

Mr. Walker, an Engineering Section Head at Sperry Gyroscope Company, continued his talk on the environmental testing of guided missiles by saying, "The most significant tests in determining system performance under the environment are high and low temperature, temperature altitude, vibration, acceleration, and shock." With respect to temperature Mr. Walker noted that a missile in flight will undergo a temperature change from 0 degrees fahrenheit to greater than 2500 degrees fahrenheit. In order to design proper functioning equipment to withstand these extremes, high and low temperature tests must be conducted to show up such items as changes in clearance and weight balance shifts, structural effects of temperature changes, gain changes in amplifiers, and operating limits of insulating and potting materials. In conducting such tests other factors besides temperature are included to simulate icing or fogging conditions during changes in environment. Tests are run with the equipment functioning, therefore, the cooling equipment has to have sufficient capacity to absorb all the heat dissipated by the systems equipment.

Similarly, vibration tests are carried out to determine mechanical effects such as variations in spring rate, center of gravity shifts, and changes in damping.

"An important part of vibration tests," Mr. Walker cited, "is the detection of resonances in structural members, wiring, and even in the shake table on which the missile is mounted in the lab. The table may develop nodes, varying with frequency which affect the transmission of force to the equipment under test. Structural members within the equipment may resonate at their own natural frequency so that with a driving displacement corresponding to 10G on a component, the internal member, at resonance may have displacements corresponding to 30G. Parts mounted on sheet metal chassis should be designed with such resonance effects in mind."

In discussing the effects of acceleration Mr. Walker said that in actual launching a missile is subjected to a force of 30 or 40G's. Shock tests for such environment are usually accomplished by dropping the equipment a specified height to a level sand bed or calibrated lead cones which provide a known deceleration.

In concluding Mr. Walker said, "Environmental testing is not an end in itself. It is a design tool to be used throughout all stages of development."

After his talk Mr. Walker showed movies of acceleration testing. At the movie's conclusion, Philip Forde, Chairman of the S.A.E. at Cornell, adjourned the meeting to the social lounge where refreshments were served.

Mr. Walker holds a Masters in Electrical Engineering from City College of New York. He joined Sperry in 1951 and has worked on control systems for the B-52 Intercontinental Bomber and guided missiles. In addition he holds sixteen U.S. Patents.

WRIGHT PREVIEWS AIR TRANSPORT

Truly mass air transportation within 10 or 15 years was predicted by Dr. T. P. Wright, vice president for research at Cornell, president of the Cornell Aeronautical Laboratory at Buffalo, and former Civil Aeronautical Administrator.

Dr. Wright envisaged in 20 years a substantial use of passenger aircraft with vertical takeoff and landing capabilities, and some with supersonic cruise speeds of 1125-1500 miles an hour—one-and-a-half to two times the speed of sound.

Dr. Wright's Cornell talk was scheduled to be given in Israel in December, as the first Biennial Lecture of the Israel Society of Aeronautical Sciences. The Middle East situation prevented his going. The lecture, presented on Feb. 19, was sponsored here by Cornell's Graduate School of Aeronautical Engineering.

Dr. Wright predicted a 12 percent increase in United States air travel through 1960 (to 35 billion passenger miles) and another 13 percent per year through 1965 (to 64.5 billion). His estimates for U.S. international travel were for 15 and 17 percent annual increases, and for

(Continued on Page 70)

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Book Review . . .

Chemical Engineering Kinetics by J. M. Smith XI/402 pages McGraw-Hill Book Company, New York, 1956, $10.50.

The importance of applied reaction kinetics in the chemical, petroleum, and allied fields has increased and is increasing rapidly. However, in industry, the application of systematic mathematical methods to the design, construction, operation, and improvement of chemical reactors has been limited, and guesswork, colored by the designer's experience, has been used much more often.

This new book is one of a very few which concerns itself with the kinetics problems which confront the reactor designer. Emphasis is made on the engineering, rather than the theoretical, approach to chemical reaction rates. After a brief review of the theory and thermodynamics which support chemical kinetics, the author concerns himself with homogeneous batch and flow and semibatch reactors, and fixed- and fluidized-bed reactors. Accompanying the discussion of heterogeneous reactions is an excellent coverage of catalytic mechanisms.

In large part the book is clear, although the nomenclature is, at times, confusing. Sample problems are scattered profusely throughout the book, and are lucidly solved. Problems at the end of each chapter, of varying difficulties, are available to the student, and teacher for further practice. Much use is made of references to published works, so that the student may extend his knowledge on any particular point with a minimum of difficulty.

It is difficult to find anything lacking in this book. Any matters in the text which are at first confusing become clear upon reading the sample problems. All in all, the work is quite satisfactory, and certainly is a significant contribution to the field of reactor design.

COLLEGE NEWS

(Continued from Page 67)

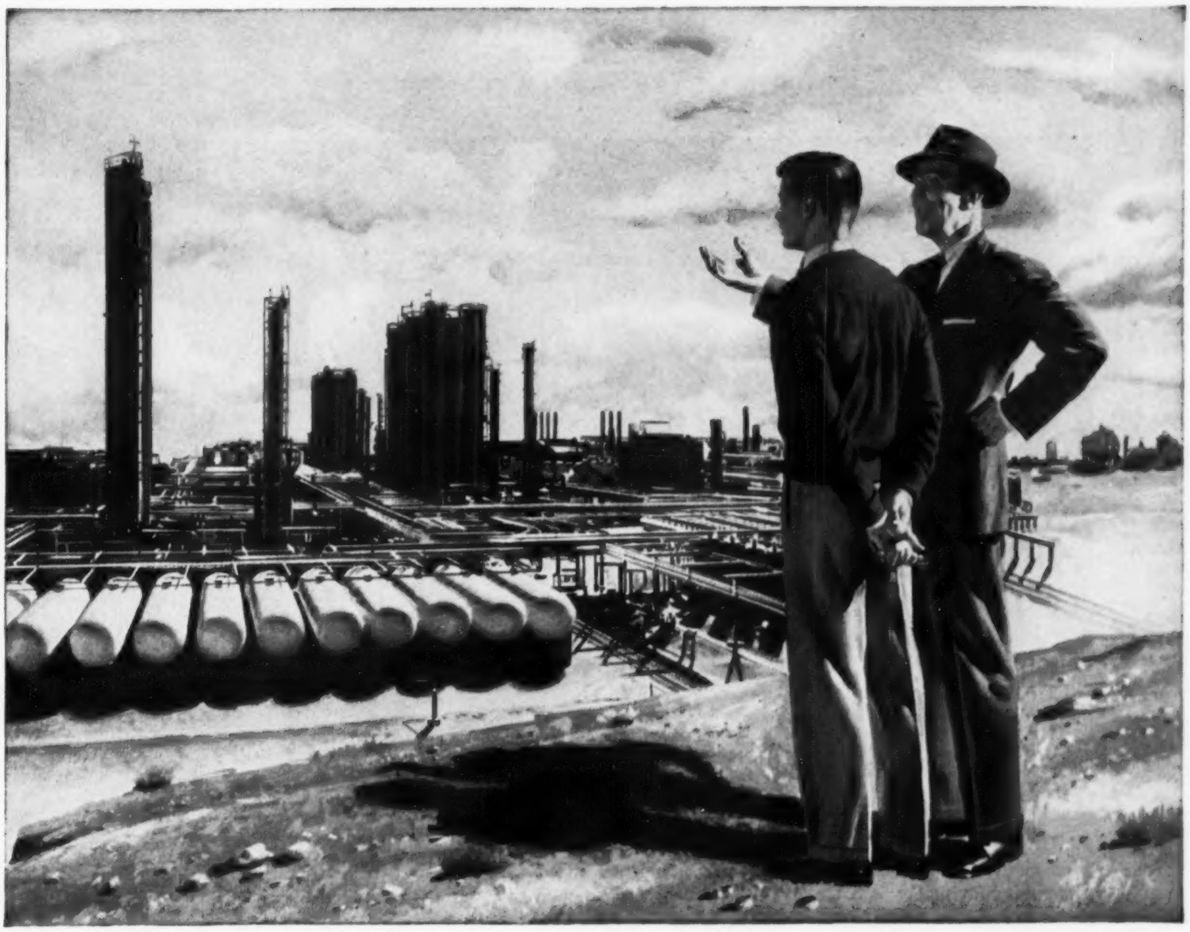
world travel 13 and 17 percent, in these two periods.

Many forecasts have erred on the pessimistic side, he stated, because they plot growth arithmetically instead of geometrically, not reckoning with "the compounding nature of past growth."

Changes that took 25 to 50 years to accomplish a century ago, he explained, can take as little as five years now. Transportation by air, he declared, has the potentials today of excelling all other forms not only in speed, but also in low cost, safety and comfort.

Dr. Wright described speed as "the commodity aviation has to sell," because it increases while other transportation methods stay the same. From today's 350 mph average, Dr. Wright said, passenger planes will reach 450 mph by 1960 and 550 by 1965, when jet aircraft predominate. Perhaps by 1975, he added, passenger planes of 1500 mph will be used for specialized services.

(Continued on Page 76)



First, Earth was all,
then the Sun, and then our Galaxy
of 100,000 million suns,
"like sand... flung down by handfuls
and both hands at once".
Now, we know our galaxy
is but one among a billion galaxies
where suns and earths
and atoms are ceaselessly created
by a Universe without
beginning and without end.
Political corollary: If nations may
forsake wars of aggression and deterrence
for a cooperative deployment
of earth's resources to explorations
in space and time, the new science of
astronautics may lead us soon
to the infinite plenty of the planets
and the stars.

worlds without end

COLLEGE NEWS

(Continued from Page 70)

Reduced fares will encourage more air travel, he continued. The average plane fare, by remaining at 5.5 cents a mile since 1935, has really dropped to about 2.8 cents when adjusted to the cost of living index (1935-39 base).

The potential number of passengers varies inversely as the cube of the fare, he said: While 10 million persons use air travel today, a fare drop to 3.31 per mile (present fare for first-class railroad travel) would bring 42 million, or four times as many, passengers as real prospects for air travel.

Lower fares will result from increased operating and aircraft efficiency, including larger jet powered planes, he explained. He mentioned the 92-seat Comet III, going into service in 1958 or 1959; the 147-seat Boeing 707, for 1958; and the 132-seat Douglas DC8, with deliveries scheduled for 1959, as well as several other jet and turbo prop types.

Increased safety encourages air travel, he continued, citing the drop in passenger fatalities since 1932 from 10.6 to 0.6 per 100 million passenger miles. He stressed a need for better traffic control, airborne collision warning devices, and airplane design for survival and fire elimination after crash.

The problem of traffic congestion and mid-air collisions will be even more serious when jet planes are in general use, Dr. Wright warned. Near misses are common occurrences now, and 65 percent of those reported occurred under Visual Flight Rule visibility conditions.

The United States has the potential for nationwide radar coverage which with computer installations, would give instructions to aircraft semi-automatically, he stated. However, airborne radar and collision warning devices would still be needed.

Jet aircraft (to be in common use by 1960) and gust alleviation (a possibility by 1965 will make air travel more comfortable, he said. Dr. Wright speculated that ram jets may be prevalent in the 1970's and nuclear powered planes by 1975.

Railroads are leaving the long-haul, first-class field entirely, Dr. Wright said, but short-haul air transportation awaits a suitable vehicle. This might well change the limits of suburban range around cities from 35 miles to 100 miles.

Problems of passenger and baggage handling, Dr. Wright continued, affect the total speed of air travel. Electronic reservation devices and detachable baggage holders are possible solutions.

The "age of concrete" threatens to accompany the age of jets, which require 10,000 foot runways. To bring airports nearer to cities, Dr. Wright said, vertical takeoff and landing planes must be developed. Steep landing and takeoff is an intermediate step. He also mentioned a need for specialized cargo aircraft, and a possibility that separate airports will be built for private planes, business planes, passenger planes, and cargo.

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shine

STRESS *and* STRAIN...

The Scotchman who emigrated to New York was sitting on a pier in New Jersey when a diver came to the surface, removed his head-gear, and lighted a cigarette.

"Hoot, mon," said the Scot, "why did nae one tell me about this? I'd have waded over maself."

• • •

Daughter: "I took Henry into the loving room last night, and . . ."

Mother: "That's LIVING dear."

Daughter: "You're telling me!"

• • •

Prof: "I suppose you wish I were dead, so you could spit on my grave."

Engineer: "No, sir, I hate to stand in line."

• • •

Many girls leave nothing to a man's imagination and everything to his self-control.

• • •

The brain of a college student is one of the most amazing things known to man. It starts to function the moment he jumps out of bed and doesn't stop until he reaches the classroom.

• • •

One skunk to another: I just haven't got it any more. Somebody must have slipped me a slug of chlorophyll.

• • •

"What is a college bred, Pop?"

"College bread is a four-year loaf made from the flavor of youth and the old man's dough."

• • •

One engineer explained his plight in a letter of exactly four words: "Long time no she."

• • •

After watching a drunk try to unlock the door to his house without success, a policeman went over and asked if he might handle the key for him.

"No thansh," the inebriated chap answered. "I gotta pretty good hold on thish key. You try and grab the housh."

• • •

Engineered English

Brazier: A garment used to minimize the effect of flutter and vibration.

Farad: A high official in the Egyptian government.

Fitting Factor: A process utilized in structural analysis whereby a factor is manipulated so as to fit a particular requirement.

Thermocouple: Newlyweds.

Stable Air: An atmosphere tinged with the odor of fertilizer.

Stress Analysis: The art of manipulating figures in such a way as to prove that a deficient structure is twice as strong as it is supposed to be.

Microfarad: A small official in the Egyptian government.

Pylon: All aboard.

• • •

Two editors gazed admiringly at the beautiful dress of the chorus girl.

"Who made her dress?" one asked his companion.

"I'm not sure, but I think it was the police."

• • •

He only drinks to calm himself,
His steadiness to improve.
Last night he got so steady,
He couldn't even move.

• • •

"Although man has learned, through evolution, to walk in an upright position, his eyes still swing from limb to limb."

• • •

Dinner guest at an Engineering Banquet: "Will you pass the nuts, Professor?"

Preoccupied Professor: "I suppose so, but I really should flunk most of them."

• • •

Textbook style: "The puissance of hydrochloric acid is incontestable; however, the corrosive residue is inharmonious with metallic persistence."

ChE style: "Hydrochloric acid eats the hell out of steel."

• • •

An ME had his arm broken while fighting for a girl's honor. It seems she wanted to keep it.

• • •

King Arthur: "I hear you've been misbehaving lately."

Knight: "In what manor, sir?"

• • •

On an airplane flight a little boy nearly drove everyone crazy. He was running up and down the aisle when the stewardess started serving coffee and ran right into her, knocking the coffee to the floor.

As he stood watching her clean up the mess, she glanced up at the boy and said, "Look, why don't you go outside and play?"

• • •

There was an attorney who journeyed to California to try an important case, promising to wire his partner the moment a decision was announced. At long last the wire came and it read, "Justice has triumphed." The partner in New York wired back, "Appeal at once."

• • •

A drunk lying on the barroom floor began to show signs of life so one joker smeared a little limberger cheese on his upper lip. The drunk rose and walked out the door. In a few minutes he returned. Then he left again only to wobble back in soon after. Shaking his head with disgust he said, "It's no use. The whole world stinks."

• • •

The Deans who think our jokes are rough
Would quickly change their views,
If they'd compare the ones we print
with the ones we're scared to use.

• • •

The cannibal king looked at the beautiful young woman about to be tossed into the cooking pot.

"Hmmm. Believe I'll have breakfast in bed this morning."

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Blind date—when you expect to meet a vision who turns out to be a sight.

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Company Reputation
Salary
Type of Job
Opportunities for Advancement and Recognition
Personnel Development Programs
Job Locations
Advanced Studies
Trained Colleagues
Employee Benefits
Company's Future